The Principal *Larrea* Bees of the Southwestern United States (Hymenoptera: Apoidea)

PAUL D. HURD, JR.
and
E. GORTON LINSLEY

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY · NUMBER 193

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ABSTRACT

Hurd, Paul D., Jr., and E. Gorton Linsley. The Principal *Larrea* Bees of the Southwestern United States (Hymenoptera: Apoidea). *Smithsonian Contributions to Zoology,* number 193, 74 pages, 18 figures, 15 tables, 1975.—This investigation focuses primarily on those ecological and evolutionary aspects involved in the natural history of the bees which depend upon the pollen, nectar, or both of the creosote bush (*Larrea tridentata*) in North America for their survival either as species or for their maintenance in viable populations. This bee-plant (bee-flower) association is examined principally by analyses of the intrafloral, geographic, diurnal, and seasonal interrelationships that exist between this fauna of bees and the plant.

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Contents

The Principal *Larrea* Bees of the Southwestern United States (Hymenoptera: Apoidea)

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Introduction

Botanists, since the writings of Gray and Hooker (1880) and Engler (1882), have been intrigued by certain similarities in the temperate floras of North and South America, particularly those elements common to the arid zones of the southwestern United States and northern Mexico and counterpart areas in Argentina and Chile (e.g., Bray, 1898, 1900; I. M. Johnston, 1940; M. C. Johnston, 1962). Prominent among these elements are members of the genus *Larrea*. There has been lack of agreement among botanists as to the appropriate name for the species of *Larrea* inhabiting North America, some regarding it as conspecific with the South American *Larrea divaricata*, others as a distinct species, *L. tridentata*. We follow Porter (1963, 1974) and Raven (1963) in utilizing the designation *Larrea tridentata* (creosote bush).

Raven (1963), in his instructive discussion of amphitropical relationships in the floras of North and South America, recognizes three groups of plants with disjunct distributions: (1) the bipolar or high-latitude, (2) the temperate, and (3) the desert groups. The desert disjuncts consist of species or species groups confined to the Sonoran and Chihuahuan desert regions of North America and to analogous desert regions centering around north Chile and northern Argentina in South America. Thus, he points out, closely similar species of *Larrea* and at least three different sections of *Prosopis* are prominent in arid zones of both continents, *Larrea tridentata* occurring throughout the Sonoran and Chihuahuan deserts and in isolated localities south to Hidalgo, and its close relative, *L. divaricata*, in the deserts of Peru, Bolivia, Chile, and Argentina. He states that the North American species is self-compatible and sets seed in isolation, citing as evidence a single shrub in the San Joaquin Valley reported by Twisselmann (1956). This interpretation is consistent with Raven's conclusion that nearly all of the plants with disjunct amphitropical distributions are self-compatible.

When considering amphitropical distributions of plants, the question as to how and when the disjunctions were formed is critical. Raven discusses several lines of evidence that can be utilized in discriminating among the various possible alternatives. One such source is the faunas associated with the disjunct plants. He emphasizes that insects, which are predominantly bisexual, are often closely tied to a particular environment and are dispersed with relative ease. Thus, if the amphitropical patterns of distribution are the result of relatively recent migration, large numbers of common groups of insects may be expected in the corresponding

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regions of temperate North and South America. On the other hand, if the plant distributions are the result of long-distance dispersal, very few common genera and species of insects would be expected.

When considering the distributions of phytophagous insects associated with disjunct amphitropical plants, the principal questions are (1) to what extent do the insects associated with the disjunct plants represent similarly disjunct species or groups of closely related species, (2) to what extent do those counterpart insects which were derived from related but distinct evolutionary lines exhibit similar means of exploiting the counterpart host plants, and (3) to what extent have more distantly related phytophagous insects developed similar methods for exploiting these same plants.

Phylogenetic studies of bees on a world basis indicate that the amphitropical bee faunas of the Americas have evolved basically from independent stocks. All presently available evidence suggests a historic lack of direct dispersal between them. Salient features of these counterpart faunas are: (1) very few genera of bees are common to both; (2) genera of bees shared by both also extend more or less continuously through the tropics; (3) no species of bee is known to occur disjunctly in the deserts of North and South America; and (4) at least among panurgine bees different genera are characteristic of the northern and southern amphitropical regions even though they occupy similar niches in each area. Thus, it is likely that convergent roles in regard to the utilization of pollen from amphitropical plants have evolved independently probably several times.

In order to develop more precise information regarding the evolutionary and ecological interrelationships of species of *Larrea* and the bees which visit them, a study is presently underway with the following objectives:

1. *Determination of the phylogenetic relationships of selected bee taxa associated with Larrea in North and South America.* The groups to be investigated include representatives of five families (Colletidae, Andrenidae, Oxaeidae, Megachilidae, and Anthophoridae). Particular emphasis is placed upon the tribe Panurgini (Andrenidae), as several genera of these bees (or large assemblages of their species) are closely associated with *Larrea*. Similar attention is also given to certain groups of species in the Megachilidae, especially of the tribes Anthidiini and Megachilini. To provide a broad base of phylogenetic contrast, species of the families Colletidae, Andrenidae, Anthophoridae, Megachilidae, Melittidae, and Oxaeidae were selected for special studies of their intrafloral relationships with *Larrea*. Information derived from these sources is expected to assist in distinguishing between convergent evolution of adaptations and adaptations derived from a common ancestor.

2. *Characterization of the results of convergent and divergent evolution, including adaptive radiation, in selected genera of bees with known amphitropical distributions in the Americas.* This has entailed investigations of morphology, pollen relationships, behavior, and seasonal responses of bees to pollen and nectar availability.

3. *Identification of the factors underlying population variation and the processes responsible for promoting convergent and divergent evolution.* This has required examination of the relationships between phylogenetic divergence and species diversity, and between the latter and ecologic differentiation in selected bee taxa representing groups of bees displaying marked oligolecty (pollen specialists) and those groups of bees exhibiting polylecty (pollen generalists).

4. *Determination of the relative dependencies of selected species of bees on the pollen of Larrea and their possible coevolutionary role.* This has involved determining the relative attractiveness of different species of *Larrea* to bees or variations in the attractiveness of the same species of *Larrea* growing under different conditions.

5. *Determination of the bee-carrying capacity of different species of Larrea and of the same species of Larrea growing under different conditions.* This has entailed studies of competition among plants for pollinators and competition among bees, especially oligolectic ones, for pollen and nectar of *Larrea* plants in different settings.

The present study is intended to provide a summary based upon our own field and laboratory research of the known geographical and seasonal distribution of the principal *Larrea*-visiting bees of the southwestern United States. The known occurrences of certain selected species are shown on the maps (Figures 1–18) with solid circles against the generalized distribution (stippling) of *Larrea* in the southwestern United States.

ACKNOWLEDGMENTS.—This is one of a series of

studies called the "Origin and Structure of Ecosystems, Integrated Research Program (IBP)" conducted by a group of 14 universities and museums. The immediate objective of this series is to determine the structural and functional similarity of ecosystems that have evolved separately but under similar climatic regimes, and which are largely or entirely formed by species with different phylogenetic histories. Two formations—(1) the Mediterranean Scrub of Chile and California and (2) the Desert Scrub of central and northern Argentina and northern Mexico and the southwestern United States—are being studied.

The present study is an integral part of the Desert Scrub Project (Solbrig, 1972) and is directed at a detailed analysis of the bee pollinators associated with the amphitropically distributed *Larrea* so as to achieve the overall objective of providing an understanding of the convergent roles assumed by the pollinator fauna of *Larrea* in North and South America by unrelated and phylogenetically distinct assemblages of bees.

We are under heavy obligation to a number of individuals, as well as several supporting agencies, who have made this study possible. The opportunity afforded the authors to perform research together, both in the laboratory and in the field, has been fundamental to the execution and completion of this study. We are, therefore, indebted to the authorities of our respective institutions who have made this possible. We gratefully acknowledge the support of this project by the National Science Foundation (GB–31191), the Smithsonian Research Foundation (SRF–430039), and the Leopold Edward Wrasse and Elvenia J. Slosson Endowment Funds of the Division of Agricultural Sciences, University of California.

We are greatly indebted to Professor and Mrs. A. E. Michelbacher and Mrs. E. G. Linsley for their dedication to the objectives of the project and to their untiring efforts in the field, especially during the intensive sampling program, which provided much of the basic information on the intrafloral ecology of the *Larrea* bees in the southwestern United States and adjacent northern Mexico. We also wish to express our gratitude for much appreciated field work on the project to Drs. G. E. Bohart of Utah State University, M. A. Cazier of Arizona State University, and Thomas J. Zavortink of the California Academy of Sciences.

Throughout the course of the project we have relied heavily upon P. H. Timberlake of the University of California, Riverside, whose knowledge and collections of the bee fauna in the southwestern United States are unparalleled in both quality and scope. He has repeatedly served as a primary source of information during our investigations. In addition, he prepared initially for us a preliminary list of the bees associated with the flowers of *Larrea* in North America and has identified or verified the identifications of the majority of the specimens we obtained in our survey and sampling program.

We also wish to acknowledge the much appreciated identifications of the smaller halictine bees made for us by Dr. George Eickwort of Cornell University. We are similarly indebted to Dr. Wallace E. LaBerge of the Illinois Natural History Survey, who provided identifications for us of some andrenine and eucerine bees.

Dr. Beryl Simpson, Department of Botany, Smithsonian Institution, has kindly performed an analysis of the pollen adhering to the scopae of many specimens obtained in the San Simon Valley of Arizona and adjacent New Mexico.

From the inception of the project we have been ably assisted in a variety of capacities by Kathleen Hale of the University of California, Berkeley. She has extracted much of the data from various collections, prepared the maps which accompany this study, and has performed most of the preparation and curation of the specimens obtained during the course of our field investigations. Rollin E. Coville, a graduate student in the Department of Entomological Sciences, University of California, Berkeley, extracted for us the pertinent label data from the specimens of *Larrea* bees in the Timberlake collection.

Finally, we wish to thank Dr. George E. Bohart for reviewing the manuscript and offering helpful suggestions. The data presented in Tables 14 and 15 were obtained by him for this project, and we gratefully acknowledge this source of valuable information.

Methods of Study

The principal sources of data utilized in this study are published records of North American bees collected at *Larrea* flowers, records obtained from specimens on deposit in museum collections, and

especially our intensive field surveys and samples of bees at flowers of *Larrea* during the spring and fall seasons of 1972 and 1973 in Arizona and New Mexico. Field surveys were also conducted in Arizona and southern California during the spring seasons of 1973 and 1974. Of the published records, we have cited primarily those that provide data that can be interpreted in terms of objectives of the project. Unfortunately few of these indicate whether or not visitors at the flowers of *Larrea* were actually taking pollen. It has not been feasible to attempt to extract such records from more than a few of the major collections in the United States. Consequently, the principal sources utilized have been the insect collections of the Berkeley, Davis, and Riverside campuses of the University of California. All three are rich in desert bees, but the Timberlake collection at Riverside is the most comprehensive assemblage of southwestern desert bees in existence and is particularly valuable because of the *Larrea* host records. Our field surveys and sampling of bees from *Larrea* flowers have been directed primarily at desert areas in the southwestern United States where collection data were previously sparse or nonexistent. Analyses of data assembled from these sources has been accomplished primarily by mapping and by plotting the frequency of collection of bees from *Larrea* flowers in relation to other plant species and the proportion of females carrying *Larrea* pollen against foreign pollens or no pollen at all. Locality records have been plotted on maps over which a generalized pattern of *Larrea* distribution is superimposed. Relative frequencies of *Larrea* flower records permitted preliminary judgments as to whether the bee species were pollen specialists (oligoleges) or pollen generalists (polyleges) and estimates of their probable value as pollinators.

Sampling Methods

Larrea-visiting bees were sampled in quarter or half-hour periods, and no bee was taken until it actually alighted on or was seen to visit a flower. Cruising bees were noted but, except for males, usually were not collected. To minimize error in marking collection vials in the field, and in labeling subsequently mounted specimens, the periods were recorded as 15 (or 30) minutes each. Actually each period was started on the quarter (or half) hour (0600, 0615, 0630, etc.) and ended 14 (or 29) minutes later when vials and labels were changed (e.g., 0614, 0629, 0644, 0659). When records were transcribed for analysis they were converted to 14- (or 29-) minute periods. We have used the 14- (or 29-) minute time periods or combined them into half-hour periods or one-hour periods, depending on how they best present the activity sequences when plotted. All times are reported as Pacific or Mountain Standard time.

All-day counts were not feasible to complete in a single 15-hour day (dawn to dusk). They were made over two-, three-, or four-day periods on days selected for similar weather patterns at the sampling site.

Larrea bee sampling was easier in the Sonoran Desert than in the Chihuahuan Desert. The Chihuahuan Desert *Larrea* biotype is stiff, in some individuals almost like manzanita, and will not bend when struck with the net. This prevents follow-through on the net swing. If a bee is working inside the plant, the collector must wait until it gradually moves outward. Frequently it will then take off immediately. Also, bees were not numerous; they varied widely in abundance from site to site even when the *Larrea* was in good bloom. Nevertheless, we took samples when they averaged as few as one individual on each 8–10 plants, which required fast walking to obtain adequate samples, to situations in which 8–10 plants would provide more bees than could be collected. *Perdita* and *Dialictus* were sometimes very abundant. However, sweep sampling for them was usually not successful and was often very hard on the nets. Under these circumstances we usually did not obtain good quantitative data, although we always took samples.

Weather was also an important factor affecting sampling. On some days, no bees flew because of heavy overcast, rain, thunderstorms, or strong winds. Nevertheless, if possible, the sites were visited and checked even though no samples could be obtained. Afternoon and evening counts in the Chihuahuan Desert sites were often impossible after the summer rains started. In several sites, although we obtained composite all-day counts, the best quantitative data available were from collections made from 0500 until late morning. We also recorded some data without vouchers to supplement collecting counts for males and females of *Caupolicana, Martinapis,* and *Protoxaea,* which

were readily identified in the field and sometimes observed but not captured. These bees were frequently undersampled because of their speed and their nectar and pollen-gathering behavior, in spite of the fact that they forage on the upper and outer branches and their large size attracts the eye.

Nectar-drinking bees proved more important as pollen vectors than had been anticipated. Thus, female *Xylocopa* often get pollen on the head when they probe the nectaries and on the underside when they grasp the flower. Also male bees of various kinds, including *Protoxaea* and *Melissodes,* become dusted with pollen and transfer it to the stigma mechanically as they seek nectar.

Wasp visitors to *Larrea* flowers usually were few, and, with some exceptions, so were beetles, flies, butterflies, etc. We decided not to try to obtain quantitative data on them since this would have diverted effort away from the bees. We collected them to the extent that time permitted, but we did not attempt a *Larrea* insect survey.

Regions and study sites	*Numbers of specimens collected in primary surveys*		
	Spring bloom	*Late summer bloom*	*Totals*
Upper Rio Grande Valley, New Mexico			
Las Cruces (Table 1)	–	419	419
Western New Mexico			
Lordsburg (Table 2)	162	–	162
San Simon Valley and Vicinity, Arizona and New Mexico			
Granite Pass (Table 3)	–	324	324
Antelope Pass (Table 4)	–	373	373
Portal (Tables 5 & 6)	1072	824	1896
Southeastern Arizona			
Douglas (Tables 7 & 8)	578	342	920
San Pedro River Valley, Arizona			
Benson	127	–	127
Naco	184	–	184
Tombstone	76	–	76
Tucson Basin, Arizona			
Tucson, 18 mi W (Tables 9 & 10)	2036	896	2932
Tucson International Airport (Table 11)	503	–	503
Colorado River Valley, Arizona and California			
Yuma (Table 12)	751	–	751
Colorado Desert, California			
Palm Springs (Table 13)	1025	–	1025
Totals	6514	3178	9692

Principal Sampling and Survey Sites

For our field investigations of the intrafloral relationships of the bees associated with *Larrea,* we selected 13 primary study sites for an intensive sampling and survey program in the southwestern United States (Tables 1–13). These sites were chosen to represent as nearly as possible an east-west transect extending across the *Larrea* belt from Las Cruces, New Mexico, to Palm Springs, California. These primary study sites and some others chosen at random in Arizona and New Mexico are grouped for discussion in this section into eight regions largely on the basis of ecogeographic similarities of the component sites. The regions are arranged sequentially from east to west. Each region and its included study sites are briefly characterized. In the table to the left we have listed the regions, as discussed, and have tabulated by study sites the numbers of specimens taken during the course of our sampling program, exclusive of the specimens of *Dialictus, Evylaeus,* and *Perdita.*

Summarized in the table that follows are the numbers of individuals for each of the 15 commonest pollen-collecting species of bees, exclusive of *Dialictus, Evylaeus,* and *Perdita,* that were taken during our surveys at the principal sampling and

Species	*Females*	*Males*	*Totals specimens*
Ancylandrena larreae	289	81	370
Caupolicana yarrowi	170	151	321
Centris cockerelli	96	46	142
Colletes clypeonitens	231	632	863
Colletes salicicola	210	211	421
Colletes wootoni	76	79	155
Hesperapis larreae	193	372	565
Heteranthidium larreae	931	1737	2668
Hoplitis biscutellae	129	51	180
Martinapis luteicornis	188	65	253
Megachile texana	328	27	355
Melissodes tristis	633	33	666
Nomia mesillensis	205	18	223
Nomia tetrazonata	598	4	602
Protoxaea gloriosa	185	62	247
Totals	4462	3569	8031

survey sites in New Mexico, Arizona, and southern California.

From the foregoing it is readily apparent that the 15 commonest species of *Larrea* bees, exclusive of the species of *Dialictus, Evylaeus,* and *Perdita,* represent more than 80 percent of the total specimens of bees (9692) obtained during our sampling program at the 13 study sites. Inclusion of the data on the excluded species of the genera mentioned would, of course, result in a few changes in the membership list of the 15 commonest species, but we do not believe that there would be an appreciable change in the overall percent of total specimens that the 15 commonest species represent.

The following accounts briefly characterize by regions, proceeding from east to west, the principal sampling and survey sites of our field program.

Upper Rio Grande Valley, New Mexico

The principal sites sampled along the upper Rio Grande Valley, New Mexico, were: Socorro, Socorro County (elev. 4600 ft), Elephant Butte, Sierra County (elev. 4200 ft), Las Cruces, Dona Ana County (elev. 3883 ft).

La Cruces (Table 1).—The sample site at Las Cruces was a 40–50 acre block of sloping vacant land in the western suburbs of the city. *Larrea* plants were scattered, mostly less than 4 ft high on the upper slopes, 6–10 ft high where the land leveled out somewhat at the base of the slope. Exposure was to the south and slightly east, and the plants had sun all day. The bloom was good but much seed had already been set. Collections were made on 12–13 August 1973. *Martinapis luteicornis* was particularly abundant at this site.

Western New Mexico

Lordsburg, Hidalgo County (Table 2).—This city is an old railroad town on the transcontinental railroad and highway across southern Arizona and New Mexico, at an altitude of 4237 ft. The site sampled was near the southern periphery of the town. It was an area dominated by *Larrea* in sandy soil with a crustlike covering. Scattered mesquites *(Prosopis juliflora)* and catclaw *(Acacia greggii)* grew among *Larrea.*

San Simon Valley and Vicinity, Arizona and New Mexico

The principal sites sampled in the San Simon Valley or its periphery were near Portal, Cochise County, Arizona (fall, 1972; spring and fall, 1973), Lake Cienega, Hidalgo County, New Mexico (fall, 1973); Antelope Pass, 5 miles west of Animas, Hidalgo County, New Mexico (fall, 1972), and Granite Pass, 22 miles north of Rodeo, Hidalgo County, New Mexico (fall, 1972, 1973).

In 1972, these sites suffered a five-month drought from 1 January to the end of May. Rainfall at Portal for December 1971 was 3.41 inches (the last, 0.32 inches falling on 31 December). On 29 May 1972, 0.13 inches fell and the records for June and July were 2.18 and 4.52 inches respectively. Although no bee samples were taken in the spring of 1972, these sites had an abundance of *Larrea*-visiting bees when checked in the spring of 1973. In the fall of 1972, 2.27 inches were recorded between 1 and 18 August and for the remainder of the month rain fell somewhere in the Valley practically every day. *Larrea* bees were abundant in both 1972 and 1973.

Granite Pass, Pelancillo Mountains (22 miles north of Rodeo, Hidalgo County, New Mexico; elev. 4460 ft) (Table 3).—This site is shaded by the mountains to the east at sunrise, and when the sun rises in the San Simon Valley below (e.g., 0551 MST), it does not reach the *Larrea* plants in the Pass until nearly an hour later (e.g., 0641 MST). The plants sampled were in the Pass, just to the south of the highest point and within 10–15 yards of the highway on the east side. Alternate pollen sources were a few *Acacia greggii* and scattered annuals, primarily *Baileya multiradiata* and scattered *Cassia lindheimeriana.* During sampling, scattered clouds were also overhead, and collections were terminated in early afternoon due to inclement weather and thunderstorms, which terminated bee flight. Samples were taken in mid-August. No honeybees were present.

Antelope Pass, Pelancillo Mountains (5 miles west of Animas, Hidalgo County, New Mexico; elev. 4400 ft) (Table 4).—This is a flat site at the top of the Pass between San Simon and Animas valleys. There were 150–200 acres of *Larrea* in relatively good bloom but going to seed rapidly, with only about one plant in 10 with fresh flowers

and buds. Most plants were 3–4 ft high, with a few 6–7 ft high. No honeybees were present. Alternate pollen sources were annuals with *Baileya multiradiata* predominant. Collections were made on 7, 8, and 10 August 1972. Heavy clouds and thunderstorms prevented sampling after 1400 MST.

PORTAL, COCHISE COUNTY (Arizona) (Tables 5, 6).—The site chosen for sampling, near this locality at the mouth of Cave Creek Canyon in the Chiricahua Mountains on the west side of the San Simon Valley, was one mile north of the town on a gentle talus slope on the west side of the San Simon Road facing east. Approximately one and one-half acres of *Larrea* were utilized for sampling. The plants were mostly 4–5 ft high with patches 8–10 ft tall. Samples were taken in the spring of 1973 and in the fall of 1972 and 1973. Honeybees were maintained at a nearby ranch and were especially numerous at *Larrea* flowers in the fall of 1972 when alternative nectar sources were scarce.

In the spring, the predominant annual in bloom was *Baileya multiradiata* Harvey and Gray; others included *Beloperone californica* Benth., *Lepidium montanum* var. *canescens* (Thellung) C. L. Hitchcock, *Zinnia pumila* Gray, *Cryptantha* sp., and *Sphaeralcea* sp. Scattered bloom was also present on *Acacia greggii* Gray, *Acacia constricta* Bentham, and *Prosopis juliflora*. *Nama* sp. and *Opuntia* sp. were also in bloom.

Baileya, Lepidium, Zinnia, Sphaeralcea laxa Wooton and Standley, *Parthenium incanum* H.B.K., *Allionia incarnata* Linnaeus, *Pectis papposa* Harvey and Gray, *Eriogonum, Flourensia cernua* DC. and *Guiterrezia microcephala* (DeCandolle), *Eriogonum fasciculatum* Bentham were also blooming in the fall as were *Prosopis juliflora, Acacia greggii,* and *A. constricta.*

SOUTHEASTERN ARIZONA

DOUGLAS MUNICIPAL AIRPORT, COCHISE COUNTY (elev. 4180 ft) (Tables 7,8)—The sampling site was along the northwest edge of the airport, mostly within a city block of the airport fence. *Larrea* plants sampled were largely along the edges of the road in this suburban residential area and in vacant lots. Most collections were made within a mile of the international border between Mexico and the United States. Probably less than an acre and one-half of *Larrea* was included in the survey area.

This site was sampled in May 1973 and in July 1972 and 1973. Relatively few other plants offered pollen competition in the immediate area. *Baileya multiradiata* Harvey and Gray and *Lepidium montanum* var. *canescens* were evident both in the spring and summer and in the fall, *Solanum elaeagnifolium* Cavanilles and *Xanthium saccharatum* Walroth. Some *Prosopis* and *Acacia* were in bloom spring and summer but they were widely scattered. In this general area *Larrea* is frequently kept as a garden plant, and we were permitted to sample plants that were well watered and had had special care.

SAN PEDRO RIVER VALLEY, ARIZONA

BENSON, COCHISE COUNTY.—Site northwest of town at an elevation of about 3600 ft. Samples were taken from *Larrea* on rocky slopes edging on and within a sandy wash. *Larrea* was represented by isolated individuals and clumps among *Acacia greggii* plants, thickets of *Prosopis glandulosa,* scattered *Opuntia* cacti, and flowering *Penstemon, Lepidium, Baileya,* and *Zinnia.*

Other localities surveyed in the San Pedro River Valley of Cochise County include Naco on the Mexican Border and Tombstone (elev. 4540 ft).

TUCSON BASIN, ARIZONA

TUCSON INTERNATIONAL AIRPORT (Table 11).—Located on a gentle sloping plain with sandy soil, dissected by small washes. There were thickets, dense and impenetrable, along with scattered acacias among the *Larrea* stands. Annuals and low perennials include *Lepidium,* grasses, cacti, *Nama, Cryptantha, Baileya,* and *Sphaeralcea.* Samples were taken on clear days with scattered clouds and some wind in the afternoon. There was no rain during sample period.

TUCSON (18 miles West on Sandario Road, off Ajo Road; elev. 2487 ft) (Table 9).—Sample site comprised about 20 acres of *Larrea* surrounded by agricultural land. *Larrea* plants were variable in height, tall along a drainage ditch, short and spaced over most of the area. Complex of smaller annuals and perennials included *Nama, Lepidium,* cacti, *Sphaeralcea,* and *Baileya.* Scattered shrubs of mesquite *(Prosopis)* were also present near the drainage area.

TUCSON (elev. 2375 ft) (Table 10).—Summer half-hour samples of *Larrea*-visiting bees were taken in a 10- to 15-acre site on Wilmot Road, 9 miles southeast of the intersection of Interstate highways 10 and 19. Several hundred plants were in bloom, mostly in an early stage with relatively small amounts of seed in evidence. Samples were taken on 6–7 August 1973.

COLORADO RIVER VALLEY, ARIZONA AND CALIFORNIA

YUMA, YUMA COUNTY (Arizona) (elev. 141 ft) (Table 12).—Our principal collections in the lower Colorado River Valley were made in the immediate vicinity of Yuma, Yuma County, Arizona. All samples were taken in the spring, during the last week of March 1973 and the first week of April 1974. Sampling sites were east of Yuma, mostly along or near U.S. Highway 95, which connects Yuma and Ehrenberg, and all were within 10 miles of the Colorado River and 15 miles of Yuma. One of the principal sites was a sand dune area with *Larrea* predominating but mesquite *(Prosopis)* also was present. Spring ephemerals were represented by *Oenothera deltoides*. Another primary site was near an irrigation canal. The soil was loose and sandy but the terrain was flat, consisting of *Larrea* interspersed with large thickets of mesquite.

COLORADO DESERT, CALIFORNIA

PALM SPRINGS (elev. 475 ft) (Table 13).—Samples were taken within the city limits in early April. The morning temperatures at this time were cool enough to require a jacket to be comfortable, suggesting that on the Colorado Desert at this time of year the dawn temperatures may be too low for flight. Our samples were taken when sunrise was between 0635 and 0638 PST. They were taken on vacant lots within the city. In the sandy areas where *Colletes* were most abundant, sand verbena and *Malacothrix* were the principal alternative pollen sources for bees. In the areas of coarser soils, *Encelia farinosa* and *Cryptantha* were the primary alternative pollen sources, although they also dominated the urban sites.

Intrafloral Relationships of Bees Associated with *Larrea* in the Southwestern United States

Bee-plant (bee-flower) relationships reflect various strategies on the part of both sets of participants. For the purposes of the present paper, we are concerned with the extent to which bees utilize the pollen and nectar of *Larrea* for their survival as species or for the maintenance of viable populations in areas where this would otherwise be difficult or impossible.

The two most commonly recognized behavioral categories with respect to pollen collection by bees are oligolecty and polylecty (see reviews by Grant, 1950, Linsley, 1958, and Baker and Hurd, 1968). *Oligolectic bees* are generally regarded as those in which the individual members of the population, throughout its range and in the presence of other pollen sources, consistently and regularly collect pollen from a single plant species or a group of related plant species, turning to other sources, if at all, only locally in the face of an absence or shortage of pollen. *Polylectic bees* are those in which the species as a whole, regardless of the extent to which individual members of the population may exhibit flower constancy in the collection of pollen, are not sharply limited in the number and kind of pollen sources utilized. Although these categories are by nature relative and not always clearly recognizable, or even definable, they do represent modes in the flower relationships of pollen-collecting bees as a whole. Consistent exploiters of *Larrea* pollen among bees which, as a species, are capable of utilizing pollen from several elements of the desert flora are conspicuous among *Larrea* visitors and play a major role as pollen vectors. Some of these have geographical ranges that coincide with that of *Larrea,* others exceed it. The more obvious members of this group are large bees, such as *Xylocopa,* and halictines like *Agapostemon,* which have long seasons, the caupolicanine colletids, and several megachilids and anthophorids.

Highly restricted oligolectic bees which depend upon *Larrea* pollen for their survival are almost all medium-size to very small species. Their geographical range is, of course, constrained by but not necessarily coextensive with that of *Larrea.* We recognize 22 species of bees as apparent *Larrea* oligoleges. These occur in the following nine genera: *Ancylan-*

drena, Colletes, Emphoropsis, Hesperapis, Heteranthidium, Hoplitis, Megandrena, Nomadopsis, and *Perdita.*

For the purposes of the present study, two further distinctions appear useful in the analysis of bee-*Larrea* relationships: (1) those bees which, although polylectic as a species, regularly gather pollen from *Larrea* where they occur within its range, either as individuals or populations, and (2) those polylectic species of bees which have a preference for the pollens of other plants but, as individuals, visit the flowers of *Larrea* for pollen, usually but not always, in small numbers. For purposes of discussion these are referred to as "regular polyleges" and "casual polyleges."

Although data regarding casual visitors are limited, it is clear that a wide variety of oligolectic and polylectic desert bees take advantage of the availability of *Larrea* nectar, although their pollen sources may be found elsewhere. This is most evident when the restricted or the preferred pollen host is not available or is in limited supply, as is frequently the situation with spring and summer annuals and ephemerals in dry years, or when the preferred pollen host produces little or no nectar, as *Solanum.* Also, in dry years, polylectic bees with marked flower preferences will turn to *Larrea* for pollen as well as nectar, when their preferred hosts are absent or are greatly reduced in number.

Nectar-gathering *Larrea* bees also fall into several categories: (1) oligolectic females that take nectar for recognizable periods before, during, and after the principal pollen-collecting period, in addition to the the nectar extracted during the pollen-collection process, (2) males of oligoleges and polylectic regulars which patrol the pollen plant seeking to mate with females, or which set up territories near or about the plants and periodically but regularly turn to the pollen plant for nectar to bioenergetically sustain themselves, (3) males and females of parasitoids of oligolectic and polylectic regulars, and (4) males and females of polylectic species which for one reason or another find *Larrea* flowers a convenient source of nectar but are not dependent upon it on a continuing basis. The first three categories may be designated "nectar-seeking regulars," the fourth as "nectar-seeking casuals."

Based upon the previously discussed criteria of relative dependencies on the pollen of *Larrea,* the species discussed later may be tentatively grouped as follows:

OLIGOLEGES

Ancylandrena larreae
Colletes clypeonitens
Colletes covilleae
Colletes larreae
Colletes salicicola
Colletes stepheni
Emphoropsis pallida
Hesperapis arida
Hesperapis larreae
Heteranthidium larreae
Hoplitis biscutellae
Megandrena enceliae
Nomadopsis foleyi
Nomadopsis larreae
Perdita covilleae
Perdita eremica
Perdita flavipes
Perdita larreae
Perdita lateralis lateralis
Perdita punctulata
Perdita semicaerulea
Perdita turgiceps

REGULAR POLYLEGES

Apis mellifera
Anthidium cockerelli
Anthidium sonorense
Ashmeadiella breviceps
Caupolicana yarrowi
Chalicodoma discorhina
Colletes louisae
Colletes wootoni
Dialictus pruinosiformis
Lasioglossum sisymbrii
Martinapis luteicornis
Megachile fucata
Megachile sidalceae
Megachile texana
Melissodes tristis
Nomia mesillensis
Nomia tetrazonata tetrazonata
Perdita luciae
Perdita marcialis
Protoxaea gloriosa
Ptiloglossa arizonensis
Ptiloglossa jonesi

CASUAL POLYLEGES

Agapostemon angelicus
Agapostemon cockerelli
Agapostemon melliventris
Agapostemon tyleri
Anthidiellum ehrhorni
Anthidium jocosum
Anthidium paroselae
Anthophora californica albomarginata
Anthophora hololeuca
Anthopora linsleyi
Anthophora urbana urbana
Bombus pennsylvanicus sonorus
Centris atripes
Centris hoffmanseggiae
Centris cockerelli resoluta
Centris pallida
Centris rhodopus
Ceratina apacheorum
Chalicodoma chilopsidis
Chalicodoma occidentalis
Chalicodoma spinotulata
Dialictus alius
Dialictus clarissimus
Dialictus clematisellus
Dialictus hudsoniellus
Dialictus hyalinus
Dialictus microlepoides
Dialictus perparvum
Evylaeus amicus
Exomalopsis solani
Halictus farinosus
Melissodes paroselae
Megachile gentilis
Megachile lippiae
Megachile policaris
Osmia clarescens
Osmia marginata
Osmia titusi
Synhalonia albescens
Synhalonia angustifrons
Synhalonia primiveris
Synhalonia venusta venusta
Xenoglossodes eriocarpi
Xylocopa californica arizonensis
Xylocopa tabaniformis androleuca
Xylocopa varipuncta

PARASITIC BEES

Coelioxys spp.
Hexepeolus rhodogyne
Epeolus mesillae
Ericrocis arizonensis
Xeromelecta larreae
Triepeolus spp.

Geographic Relationships of Bees Associated with *Larrea* in the Southwestern United States

Most biologists recognize four major subdivisions of the North American deserts: the Great Basin Desert, the Mojave Desert, the Sonoran Desert, and the Chihuahuan Desert (cf. Shreve, 1942). Since *Larrea* is a dominant, conspicuous, and widely distributed plant in all but the first of these subdivisions, it is not surprising that alone or in different combinations with other widespread plants it has been utilized not only for defining major desert categories but also in various refinements of these classifications. Since these provide useful and convenient terminology for summarizing the geographic ranges of bees associated with *Larrea,* they are briefly discussed as follows:

MOJAVE (Mohave) DESERT.—This is an upland desert of transmontane southern California and the southernmost portion of Nevada east of the southern Sierra Nevada and San Gabriel mountains, north of the San Bernardino mountains, and west of the Colorado River. Elevations are mostly between 600 and 1200 meters and rainfall ranges from less than 50 mm in the east to approximately 125 mm in the west. Precipitation occurs in the winter months. A very open stand of *Larrea tridentata* and *Franseria dumosa* form the groundwork of the vegetation (Shreve and Wiggins, 1964), and the northern limits of the Mojave Desert are defined by the northern limits of *Larrea.* The *Larrea* plants bloom primarily in April, May, and early June.

Although the distinctness of the vegetation characteristics of the Mojave and Colorado deserts have been emphasized by Parish (1930) and others before him, not all biologists have recognized this desert as a major subdivision. Shreve (1925) considered the names of the two deserts as of geopraphical rather than botanical value, but adopted the terminology "Mojave Desert" later. Munz (1959) recognized that the Mojave and Colorado deserts differ in many respects but considered the two together because the "Creosote Bush Scrub" occupies the largest single area in both. Dice (1939) included the Mojave in the "Sonoran Biotic Province" and Jaeger (1957) treated it as a subdivision of the Sonoran Desert.

SONORAN DESERT.—The Sonoran Desert occupies the region in the United States and Mexico which surrounds the upper two-thirds of the Gulf of California (Shreve and Wiggins, 1964). Various biologists have mapped or described their concepts of a Sonoran biotic province (e.g., Dice, 1939; Burt, 1938) or a Sonoran Desert based upon phytogeographic and physical considerations (see especially, Shreve, 1936, 1942, 1951). For purposes of the present paper we use the term in the sense of Shreve and Wiggins and generally accept the boundaries expressed in their maps. According to their data, elevations range from sea level to 1050 meters, precipitation from almost nothing in parts of the west to 330 mm on the eastern edge. Rainfall occurs in winter in the western half and in both winter and summer in the east.

Because of regional differences in elevation, rainfall, temperatures, and vegetation within the Sonoran Desert, further subdivisions have been proposed. Shreve and Wiggins (1964) recognize seven of these on purely vegetational grounds, two of which occur in the United States, the Lower Colorado Valley and the Arizona Upland. The treatments of these vegetational subdivisions are derived largely from their characterizations.

THE LOWER COLORADO VALLEY (Larrea-Franseria Desert; Microphyllous Desert).—Quoting from Shreve and Wiggins, in part, this is the largest subdivision of the Sonoran Desert, occupying the lower drainages of the Colorado and Gila rivers, the Salton Basin, the extreme east coast of Baja California as far south as Bahia Los Angeles, and all of Sonora lying below 400 meters as far south as the valley of the Rio Magdalena. In this region the two shrubby plants which vastly outnumber all others are *Larrea tridentata* and *Franseria dumosa.* The area receives only winter rainfall.

Historically, that portion of the Lower Colorado Valley lying west of the Colorado River and north of Mexico has been called the *Colorado Desert* (cf. Jaeger, 1957; Marks, 1950; Parish, 1930; Shreve, 1925). The lowland areas of the southwestern quarter of Arizona, east of the Colorado River and west of the Arizona Upland, have sometimes been designated the *Yuman Desert* (cf. Jaeger, 1957). However, the separation of the Colorado and Yuman deserts at the Colorado River is arbitrary and follows a political rather than a biological boundary. Although we might have preferred to see the long-established term "Colorado Desert" extended to include the area referred to as "Lower Colorado

Valley" by Shreve (1951), we accept and utilize the latter designation here.

THE ARIZONA UPLAND (Cercidium-Opuntia region; Crassicaulescent Desert).—Shreve and Wiggins (1964) include under this designation the northeastern part of the Sonoran Desert, mainly in Arizona, partly in northern Sonora, lying at elevations between 150 and 950 meters, and largely draining into the Gila River (see Shantz and Piemeisel, 1924, for a detailed comparison of vegetation types in the Coachella Valley and the Gila Valley). *Larrea* is a conspicuous plant in nearly all situations, but *Cercidium microphyllum, Prosopis juliflora* var. *velutina, Olneya tesota,* and *Fouquieria splendens* are also important elements of the vegetation as are cacti.

THE CHIHUAHUAN DESERT.—The Chihuahuan Desert is usually defined to include the drainage basin of the Rio Grande in southern New Mexico, western Texas (the Lower Valley of the Pecos River), the eastern half of Chihuahua and the western half of Coahuila, and also parts of Durango, Zacatecas, Nuevo Leon, and San Luis Potosi (Shreve and Wiggins, 1964). The elevations are mainly above 1070 meters and the precipitation ranges from 70–500 mm, of which 70–80 percent falls between the middle of June and the middle of September (Shreve and Wiggins, 1964). Characteristic plants include *Larrea tridentata* and *Flourensia cernua.* The *Larrea* plants bloom in response to both spring and summer rains, as in the Arizona Upland of the eastern Sonoran Desert.

Maps of the Chihuahuan and Sonoran deserts provided by Shreve (1936) and Jaeger (1957) show a wide separation between the two. However, Chihuahuan biotic elements, including *Larrea* and *Flourensia,* do extend into western New Mexico and southeastern Arizona, as recognized by Kearney and Peebles (1951) and shown by the maps of Küchler (1964). Shreve excludes these areas on the grounds that they originally supported a fairly heavy stand of perennial grasses and that desert plants were much less abundant under original conditions.

Analyses of segments of the Chihuahuan Desert vegetation have been provided for the Mesilla Valley region (Fosberg, 1940), the uplands and washes of the Rio Grande Valley in New Mexico (Gardner, 1951), western Texas (Muller, 1940), and Chihuahua (Shreve, 1939).

GEOGRAPHICAL RANGES OF *Larrea* BEES.—The geographical ranges of the flower-visiting bees of *Larrea* are of two major types: (1) those which are restricted to the deserts of the southwestern United States and northern Mexico and whose distribution is coextensive with or enclosed within the geographical range of *Larrea,* and (2) those which are more widely distributed in western North America but whose distribution includes all or part of the range of *Larrea.* The first group includes the 57 pollen-collecting species most intimately associated with the flowers of *Larrea* (22 oligoleges, 13 regular polyleges, and 22 casual polyleges), and may be subdivided into: (a) those species generally distributed throughout the range of *Larrea* (14 species), (b) those primarily confined to the Chihuahuan Desert of New Mexico, Texas, and Chihuahua (6 species), (c) those primarily centered in the Sonoran Desert of Arizona, northwestern Mexico, and southern California (7 species), (d) those occurring on the Chihuahuan and Sonoran deserts (8 species), (e) those primarily limited to the Colorado Desert (4 species), (f) those occurring on the Sonoran and Mojave deserts (10 species), (g) those restricted to the Colorado and Mojave deserts of California and immediately adjacent areas (7 species), and (h) those primarily centered in the Mojave Desert (1 species). The second category includes 33 pollen-collecting species (9 regular polyleges and 24 casual polyleges) and may be subdivided into: (a) species whose range is principally centered in the deserts but substantially exceeds them (13 species), and (b) wide-ranging species whose distribution includes all or part of the southwestern deserts but falls primarily outside of these areas (20 species).

Obviously, these categories are to some extent arbitrary and overlapping, but nevertheless, the species treated here may be tentatively categorized on these bases as follows:

1. Species restricted to deserts of southwestern United States and northern Mexico.

a. Species generally distributed in *Larrea* zones.

OLIGOLEGES

Colletes salicicola — *Hoplitis biscutellae*
Hesperapis larreae — *Perdita larreae*
Heteranthidium larreae

REGULAR POLYLEGES

Anthidium cockerelli — *Colletes louisae* — *Colletes wootoni*

CASUAL POLYLEGES

Anthidium paroselae *Chalicodoma spinotulata*
Chalicodoma chilopsidis *Exomalopsis solani*
Chalicodoma occidentalis *Xenoglossodes eriocarpi*

PARASITIC BEES

Xeromelecta larreae

b. Species primarily centered in the Chihuahuan Desert.

OLIGOLEGES

Perdita semicaerulea

REGULAR POLYLEGES

Caupolicana yarrowi *Ptiloglossa arizonensis*
Protoxaea gloriosa *Ptiloglossa jonesi*

CASUAL POLYLEGES

Dialictus clarissimus

c. Species primarily centered in the Sonoran Desert.

OLIGOLEGES

Colletes larreae *Megandrena enceliae* *Perdita lateralis*

CASUAL POLYLEGES

Anthophora californica albomarginata *Centris pallida*
Anthophora hololeuca *Synhalonia venusta venusta*

PARASITIC BEES

Ericrocis arizonensis

d. Species primarily centered in the Chihuahuan and Sonoran deserts.

REGULAR POLYLEGES

Martinapis luteicornis *Perdita luciae decora* *Perdita marcialis*

CASUAL POLYLEGES

Centris rhodopus *Dialictus perparvum*
Dialictus alius *Osmia clarescens*
Dialictus clematisellus

PARASITIC BEES

Epeolus mesillae

e. Species primarily centered in the Colorado Desert.

OLIGOLEGES

Colletes stepheni *Emphoropsis pallida*

CASUAL POLYLEGES

Osmia marginata *Osmia titusi*

PARASITIC BEES

Hexepeolus rhodogyne

f. Species primarily centered in the Sonoran and Mojave deserts.

OLIGOLEGES

Ancylandrena larreae *Perdita covilleae*
Colletes clypeonitens *Perdita eremica*
Colletes covilleae

REGULAR POLYLEGES

Anthidium sonorense *Chalicodoma discorhina*
Ashmeadiella breviceps

CASUAL POLYLEGES

Centris cockerelli resoluta *Synhalonia albescens*

g. Species primarily centered in the Colorado and Mojave deserts.

OLIGOLEGES

Hesperapis arida *Perdita flavipes*
Nomadopsis foleyi *Perdita punctulata*
Nomadopsis larreae *Perdita turgiceps*

CASUAL POLYLEGES

Synhalonia primiveris

h. Species primarily centered in the Mojave Desert.

CASUAL POLYLEGES

Anthophora linsleyi

2. Species widely distributed in western North America but whose geographic ranges include all or part of the geographic range of *Larrea*.

a. Species primarily centered in the deserts but whose geographic ranges substantially exceed this area.

REGULAR POLYLEGES

Megachile fucata *Nomia mesillensis*
Megachile sidalceae *Nomia tetrazonata*

CASUAL POLYLEGES

Anthidiellum ehrhorni *Xylocopa californica arizonensis*
Centris atripes
Centris hoffmanseggiae *Xylocopa tabaniformis androleuca*
Ceratina apacheorum
Evylaeus amicus *Xylocopa varipuncta*
Melissodes paroselae

PARASITIC BEES

Coelioxys spp. *Triepeolus* spp.

b. Species of widespread distribution whose geographic ranges include all or part of the desert areas.

REGULAR POLYLEGES

Apis mellifera	*Megachile texana*
Dialictus pruinosiformis	*Melissodes tristis*
Lasioglossum sisymbrii	

CASUAL POLYLEGES

Agapostemon angelicus	*Dialictus hudsoniellus*
Agapostemon cockerelli	*Dialictus hyalinus*
Agapostemon melliventris	*Dialictus microlepoides*
Agapostemon tyleri	*Halictus farinosus*
Anthidium jocosum	*Megachile gentilis*
Anthophora urbana urbana	*Megachile lippiae*
Bombus pennsylvanicus sonorus	*Megachile policaris*
	Synhalonia angustifrons

PARASITIC BEES

Coelioxys spp.	*Triepeolus* spp.

These assignments will undoubtedly require adjustment as field surveys of bees visiting the flowers of *Larrea* become more complete. It seems particularly likely that some of the species presently known only from the Colorado and Mojave deserts will be found to occur more widely in the Sonoran Desert of Arizona and northern Mexico, although undoubtedly some of this apparent precinctiveness is real. This is especially evident from the known distribution of the 22 species of *Larrea* oligoleges. Thus only five of these occur generally throughout the *Larrea* areas of the southwestern United States, while the majority of the oligoleges (17 species) occupy precinctive ranges within these areas. With the exception of *Perdita semicaerulea,* which is the only oligolege primarily centered in the Chihuahuan Desert, all of the other precinctively distributed oligoleges are either primarily centered within the Sonoran Desert, including its various subdivisions (5 species), or are primarily centered in the combined Sonoran and Mojave deserts (11 species). There are no known oligoleges either restricted to or primarily centered in the Mojave Desert.

Geographic Affinities of Southwestern *Larrea* Oligoleges and Regular Polyleges

As is true of southwestern desert bees in general (Michener, 1940; Hurd, 1966), the genera of the bees which regularly visit *Larrea* may be rather readily identified as having northern (Holarctic) or southern (Neotropical) affinities. However, the immediate affinities of the species involved may not be so clear, and it is obvious that in some genera a disproportionate number of species have evolved as *Larrea* oligoleges *(Colletes* spp., *Perdita* spp.).

In the southwestern United States there are 35 genera of pollen-collecting bees that contain one or more species dependent upon the pollen and nectar of *Larrea* either as polyleges (68 species) or as oligoleges (22 species). All of these genera, except the presumed amphitropically distributed anthophorid genus *Martinapis,* are either found only in North America (15 genera) or occur on both the North and South American continents (20 genera) and range for varying distances more or less continuously through the tropics, into the temperate regions of both continents. However, the introduced European honeybee (*Apis mellifera*), which occurs over much of both continents, is the only species of the genera present in the temperate regions of both North and South America.

Except for primitively social bees (Halictidae) and social bees (*Bombus*) and a few megachilids and anthophorids which have more than one annual generation, many of the vernal bees associated with *Larrea* have northern affinities (e.g., *Colletes, Hoplitis, Osmia*), but their immediate relatives are mostly western North American, as would be expected. Others belong to genera largely confined to or most numerous in western North America (e.g., *Emphoropsis, Hesperapis, Nomia*), and still others represent genera which have either evolved in or become restricted to the southwestern deserts (e.g., *Ancylandrena, Megandrena*).

On the other hand, some of the most conspicuous of the aestival-autumnal bees associated with *Larrea* in the second period of annual bloom have southern or Neotropical affinities (e.g. *Caupolicana, Protoxaea, Ptiloglossa*).

Seasonal Occurrence of Bees Associated with *Larrea* in the Southwestern United States

As is well known, *Larrea* blooms in the spring throughout most of its range in southwestern United States and northern Mexico and again in late summer and fall in those parts of its range which receive summer rains. Under these circumstances, the complex of bee visitors in the two flowering seasons differs.

While our studies reveal that there are 90 species of pollen-collecting bees associated with *Larrea* (22 oligoleges, 22 regular polyleges, and 46 casual poly-

leges), the vast majority of these species (82) are present during the spring bloom (22 oligoleges, 17 regular polyleges, and 43 casual polyleges). Some of these species (39) also occur during the late summer and fall bloom (2 oligoleges, 11 regular polyleges, and 26 casual polyleges) with a few additional species (8) that are not present during the spring bloom (5 regular polyleges and 3 casual polyleges). Thus nearly twice as many species of pollen-collecting bees (82) occur during the spring bloom as are present during the late summer and fall bloom (47 species).

Of the 22 known species of *Larrea* oligoleges, the majority (20 species) have only a single annual generation and are active only during the spring bloom of *Larrea*. Only two species of these—*Perdita (Perditella) larreae* and *P. (Perdita) semicaerulea*—produce two annual generations and consequently are the only *Larrea* oligoleges present during both the first and second flowering periods of *Larrea*. Even though there are about an equal number of regular polyleges present during the spring bloom (17 species) and the late summer and fall bloom (16 species), there is a larger number of casual polyleges present during the spring bloom (43 species) than during the late summer and fall bloom (29 species).

Apart from the greater numbers of species of pollen-collecting bees associated with the spring bloom of *Larrea*, it is significant that all the species of *Larrea* oligoleges are dependent upon the spring bloom for their survival and only two of these reappear during the second bloom. Thus there are no oligoleges limited to the second flowering period of *Larrea*, and further there are no species of bees that are entirely dependent upon the second bloom of *Larrea* for their survival.

Since the spring bloom of *Larrea* is normally nearly coextensive with the range of that plant in North America, and since the second bloom is restricted to those areas within the geographic range of *Larrea* which normally receive summer rains, it is almost axiomatic that one would expect to find a greater number of species associated with *Larrea* during the spring bloom simply because of the greater geographic area involved. There is some evidence which suggests that the annual pattern of summer rainfall upon which the second bloom of *Larrea* is dependent is more erratic than that which falls during the winter and spring. If so, this would obviously further reduce and more generally randomize the geographic locations and extent of the second bloom and consequently the numbers of species associated with the second bloom. Even though this could explain why in geographic terms there are fewer polyleges present during the second bloom, it does not satisfactorily explain why no oligoleges have evolved in response to the second bloom of *Larrea*.

Among the several possible explanations, it would appear that under the present climatic regime, it is the spring bloom of *Larrea* which offers annually as well as geographically the more consistently reliable source of food (pollen and nectar). Clearly under the climatic conditions affecting the second bloom, there is less certainty on a local geographic basis that the food source will be available on a sustained annual basis. Under either set of circumstances the polyleges are able to readily adjust to available food sources since they are not solely dependent upon a single source of pollen as are the oligoleges.

Included in the following list and arranged according to the season of activity at the flowers of *Larrea* are the 90 species of pollen-collecting bees and the several species of parasitic bees which frequently seek nectar in the company of their pollen-collecting hosts. It will be noted that the parasitic species of bees exhibit the same seasonality of visitation at the flowers as do their hosts.

Bees Visiting *Larrea* in the Spring Only

Oligoleges

Ancylandrena larreae
Colletes clypeonitens
Colletes covilleae
Colletes larreae
Colletes salicicola
Colletes stepheni
Emphoropsis pallida
Hesperapis arida
Hesperapis larreae
Heteranthidium larreae
Hoplitis biscutellae
Megandrena enceliae
Nomadopsis foleyi
Nomadopsis larreae
Perdita covilleae
Perdita eremica
Perdita flavipes
Perdita lateralis
Perdita punctulata
Perdita turgiceps

Regular Polyleges

Anthidium cockerelli
Anthidium sonorense
Ashmeadiella breviceps
Chalicodoma discorhina
Megachile fucata
Perdita luciae

Casual Polyleges

Anthidium jocosum
Anthophora californica albomarginata
Anthophora hololeuca
Anthophora linsleyi
Centris cockerelli resoluta

Centris hoffmanseggiae
Centris pallida
Chalicodoma chilopsidis
Dialictus alius
Dialictus hudsoniellus
Osmia clarescens
Osmia marginata
Osmia titusi
Synhalonia albescens
Synhalonia angustifrons
Synhalonia primiveris
Synhalonia venusta venusta

PARASITIC BEES

Epeolus mesillae
Hexepeolus rhodogyne
Xeromelecta larreae

Bees Visiting *Larrea* in the Spring and in Late Summer and Fall

OLIGOLEGES

Perdita larreae
Perdita semicaerulea

REGULAR POLYLEGES

Apis mellifera
Colletes louisae
Colletes wootoni
Dialictus pruinosiformis
Lasioglossum sisymbrii
Martinapis luteicornis
Melissodes tristis
Megachile sidalceae
Megachile texana
Nomia tetrazonata
Perdita marcialis

CASUAL POLYLEGES

Agapostemon angelicus
Agapostemon cockerelli
Agapostemon melliventris
Agapostemon tyleri
Anthidiellum ehrhorni
Anthidium paroselae
Anthophora urbana urbana
Bombus pennsylvanicus sonorus
Centris atripes
Centris rhodopus
Ceratina apacheorum
Chalicodoma occidentalis
Dialictus clarissimus
Dialictus clematisellus
Dialictus hyalinus
Dialictus microlepoides
Evylaeus amicus
Halictus farinosus
Megachile gentilis
Megachile lippiae
Megachile policaris
Melissodes paroselae
Xylocopa californica arizonensis
Xylocopa tabaniformis androleuca
Xylocopa varipuncta

PARASITIC BEES

Coelioxys spp.
Ericrocis arizonensis

Bees Visiting *Larrea* in Late Summer and Fall Only

REGULAR POLYLEGES

Caupolicana yarrowi
Nomia mesillensis
Protoxaea gloriosa
Ptiloglossa arizonensis
Ptiloglossa jonesi

CASUAL POLYLEGES

Chalicodoma spinotulata
Exomalopsis solani
Xenoglossodes eriocarpi

PARASITIC BEES

Triepeolus spp.

Diurnal Patterns of Pollen Collection

All-day sampling of *Larrea* bees, in weather conducive to flight activity, clearly reveals that some species exploit the pollen in the early hours between dawn and sunrise and the period just before and after sunset. Others appear about sunrise and work until midmorning. Still others are active from midmorning to early afternoon and a fourth group is represented at the flowers throughout much of the day. These periods overlap to some extent and are modified by inclement weather or overcast sky, but these differences in behavior are unmistakable. In some localities, where exposure of the plants to direct sunlight is delayed by a concentrated shield of tall plants or intervening hills and the like, the onset of the diurnal sequence likewise may be significantly delayed, but once commenced the same sequence of activity is observed, although often compressed in time. Consequently, under these exceptional conditions it is possible to verify the constancy of the sequence, even though it is initiated later and continues longer. In this sequence, the first bees at the flowers usually are the largest, most active, and often the most aggressive (e.g., *Caupolicana, Martinapis*); the smaller bees appear later (e.g., *Megachile, Melissodes*), and the smallest are active in the middle of the day (e.g., *Perdita*). Exception to this generalization includes the species of *Agapostemon,* which when actively taking pollen from *Larrea* may be the first bees to arrive at the plants. Although this division of activity periods appears to minimize intraspecific competition and to assure the largest bees access to the greatest amount of pollen, it does not necessarily follow that the sequential order evolved in response to competitive pressures.

Other factors may have had a major role in determining the order of the sequence, such as stress produced by the physical environment. When the sequence of *Larrea* bees is examined closely, it is evident that the earliest bee visitors not only are usually the largest but also are usually dark colored, permitting a maximum of heat absorption in the early morning hours, a disadvantage later in the day. These bees fly rapidly, take pollen from high on the outside of the plant, and make no attempt to avoid exposure to the rays of the rising sun. Those bees which are active in midmorning most commonly work on the shady side of the plant or

within it. They are often lighter colored or have whitish pubescence. The smaller more brightly colored bees active in the middle of the day are most frequently found working deep inside the plant where they receive the maximum of shade. This sequential behavior, while presumably minimizing environmental stress, also results in reduced competition for pollen, since the outer flowers are exploited for pollen first, the innermost, last. Thus, although cause and effect are difficult to distinguish, it seems clear that sequential activity at the flowers tends to reduce stress from both the physical and biological environment.

Species Accounts

In the discussions that follow, the species are arranged in the phylogenetic sequence of the currently accepted classification of bees. All eight families of bees present on the North American continent contain at least some species which, as discussed elsewhere in this study, utilize the pollen and nectar of *Larrea* with sufficient regularity to indicate a degree of dependence upon *Larrea* for their survival as species or for their maintenance in viable populations in areas where they would otherwise be unable to do so or do so only with difficulty. In addition, there are a number of parasitic species of bees which visit the flowers of *Larrea* for nectar, often in the company of their pollen-collecting host species. These species are included in this study and discussed under their respective generic accounts that follow because, in addition to their dependence on nectar for energy, they sometimes transport pollen which accidentally adheres to their bodies or appendages and is available for pollination. While theoretically it is possible that every species of bee which occurs where *Larrea* grows could ultimately be found at its flowers, it is evident that such exceptional visitations for whatever purpose are of little or no evolutionary significance.

We have excluded from this summary a number of additional species, both pollen-collecting and parasitic species, which rarely or only exceptionally visit the flowers of *Larrea*. These include, for example, certain species in *Anthophora (A. coptognatha, A. forbesi,* and *A. salazariae), Ashmeadiella (A. bigeloviae, A. cazieri, A. femorata,* and *A. rhodognatha), Dialictus (D. nevadensis, D. punctatoventris,* and *D. tegulariformis), Evylaeus (E. arizonensis* and *E. ruficornis), Megachile (M. newberryae, M. pseudolegalis,* and *M. xerophila), Osmia (O. subfasciata),* and *Perdita (P. dentata, P. erythropyga, P. eucnides, P. exclamans, P. eximia, P. fulvicauda, P. genalis, P. mojavensis, P. mortuaria, P. numerata,* and *P. ovaliceps).* Other species so excluded include some species in the genera *Andrena, Anthocopa, Diadasia, Dufourea, Hylaeus, Nomada, Proteriades,* and *Townsendiella.* Moreover, we have excluded from this investigation those species of bees whose intrafloral relationships are either unknown or insufficiently known to warrant an evaluation of their possible dependency upon the pollen and nectar of *Larrea.*

Listed and enumerated below in the same phylogenetic order as in the species accounts are the 90 species of pollen-collecting bees which exhibit at least some dependence on the pollen of *Larrea.* Each species is classed according to the three recognized states of pollen dependency on *Larrea,* namely, casual polylege, regular polylege, and oligolege. Also provided in this list is information on which flowering season(s) of *Larrea* each of the pollen-collecting species occurs, namely spring bloom, late summer and fall bloom, or both periods of bloom. For convenience of listing, these seasons of flowering are cited below as: spring, summer, or spring and summer.

COLLETIDAE

1. *Caupolicana yarrowi*	regular polylege	summer
2. *Ptiloglossa arizonensis*	regular polylege	summer
3. *Ptiloglossa jonesi*	regular polylege	summer
4. *Colletes clypeonitens*	oligolege	spring
5. *Colletes covilleae*	oligolege	spring
6. *Colletes larreae*	oligolege	spring
7. *Colletes louisae*	regular polylege	spring and summer
8. *Colletes salicicola*	oligolege	spring
9. *Colletes stepheni*	oligolege	spring
10. *Colletes wootoni*	regular polylege	spring and summer

ANDRENIDAE

1. *Ancylandrena larreae*	oligolege	spring
2. *Megandrena enceliae*	oligolege	spring
3. *Perdita flavipes*	oligolege	spring
4. *Perdita covilleae*	oligolege	spring
5. *Perdita punctulata*	oligolege	spring
6. *Perdita semicaerulea*	oligolege	spring and summer
7. *Perdita eremica*	oligolege	spring
8. *Perdita luciae decora*	regular polylege	spring
9. *Perdita lateralis lateralis*	oligolege	spring
10. *Perdita larreae*	oligolege	spring and summer
11. *Perdita marcialis*	regular polylege	spring and summer
12. *Perdita turgiceps*	oligolege	spring
13. *Nomadopsis foleyi*	oligolege	spring
14. *Nomadopsis larreae*	oligolege	spring

OXAEIDAE

1. *Protoxaea gloriosa*	regular polylege	summer

HALICTIDAE

1. *Halictus farinosus*	casual polylege	spring and summer
2. *Lasioglossum sisymbrii*	regular polylege	spring and summer
3. *Evylaeus amicus*	casual polylege	spring and summer
4. *Dialictus alius*	casual polylege	spring
5. *Dialictus clarissimus*	casual polylege	spring and summer
6. *Dialictus clematisellus*	casual polylege	spring and summer
7. *Dialictus hudsoniellus*	casual polylege	spring
8. *Dialictus hyalinus*	casual polylege	spring and summer
9. *Dialictus microlepoides*	casual polylege	spring and summer
10. *Dialictus perparvum*	casual polylege	spring and summer
11. *Dialictus pruinosiformis*	regular polylege	spring and summer
12. *Agapostemon angelicus*	casual polylege	spring and summer
13. *Agapostemon cockerelli*	casual polylege	spring and summer
14. *Agapostemon melliventris*	casual polylege	spring and summer
15. *Agapostemon tyleri*	casual polylege	spring and summer
16. *Nomia mesillensis*	regular polylege	summer
17. *Nomia tetrazonata tetrazonata*	regular polylege	spring and summer

MELITTIDAE

1. *Hesperapis arida*	oligolege	spring
2. *Hesperapis larreae*	oligolege	spring

MEGACHILIDAE

1. *Heteranthidum larreae*	oligolege	spring
2. *Anthidium cockerelli*	regular polylege	spring
3. *Anthidium jocosum*	casual polylege	spring
4. *Anthidium paroselae*	casual polylege	spring and summer
5. *Anthidium sonorense*	regular polylege	spring
6. *Anthidiellum ehrhorni*	casual polylege	spring and summer
7. *Ashmeadiella breviceps*	regular polylege	spring
8. *Hoplitis biscutellae*	oligolege	spring
9. *Osmia clarescens*	casual polylege	spring
10. *Osmia marginata*	casual polylege	spring
11. *Osmia titusi*	casual polylege	spring
12. *Megachile gentilis*	casual polylege	spring and summer
13. *Megachile lippiae*	casual polylege	spring and summer
14. *Megachile texana*	regular polylege	spring and summer
15. *Megachile fucata*	regular polylege	spring
16. *Megachile sidalceae*	regular polylege	spring and summer

17. *Megachile policaris*	casual polylege	spring and summer
18. *Chalicodoma chilopsidis*	casual polylege	spring
19. *Chalicodoma discorhina*	regular polylege	spring
20. *Chalicodoma occidentalis*	casual polylege	spring and summer
21. *Chalicodoma spinotulata*	casual polylege	summer
ANTHOPHORIDAE		
1. *Exomalopsis solani*	casual polylege	summer
2. *Martinapis luteicornis*	regular polylege	spring and summer
3. *Melissodes paroselae*	casual polylege	spring and summer
4. *Melissodes tristis*	regular polylege	spring and summer
5. *Xenoglossodes eriocarpi*	casual polylege	summer
6. *Synhalonia albescens*	casual polylege	spring
7. *Synhalonia angustifrons*	casual polylege	spring
8. *Synhalonia primiveris*	casual polylege	spring
9. *Synhalonia venusta venusta*	casual polylege	spring
10. *Anthophora linsleyi*	casual polylege	spring
11. *Anthophora urbana urbana*	casual polylege	spring and summer
12. *Anthophora californica albomarginata*	casual polylege	spring
13. *Anthophora hololeuca*	casual polylege	spring
14. *Emphoropsis pallida*	oligolege	spring
15. *Centris hoffmanseggiae*	casual polylege	spring
16. *Centris pallida*	casual polylege	spring
17. *Centris atripes*	casual polylege	spring and summer
18. *Centris cockerelli resoluta*	casual polylege	spring
19. *Centris rhodopus*	casual polylege	spring and summer
20. *Ceratina apacheorum*	casual polylege	spring and summer
21. *Xylocopa californica arizonensis*	casual polylege	spring and summer
22. *Xylocopa tabaniformis androleuca*	casual polylege	spring and summer
23. *Xylocopa varipuncta*	casual polylege	spring and summer
APIDAE		
1. *Bombus pennsylvanicus sonorus*	casual polylege	spring and summer
2. *Apis mellifera*	regular polylege	spring and summer

Family COLLETIDAE

Our field investigations reveal the regular presence of 10 species of this family at the flowers of *Larrea* in the southwestern United States. Three of these species, *Caupolicana yarrowi, Ptiloglossa arizonensis,* and *Pt. jonesi* depend to a large degree, but not exclusively, upon the pollen and nectar of *Larrea* during its second season of flowering in the late summer and autumn. Of the seven other species of colletids, all are members of the genus *Colletes,* and with the exception of two species (*C. louisae* and *C. wootoni*) all are oligoleges of *Larrea* during its spring bloom. The two above-named species of *Colletes* are regular polyleges of *Larrea* and can be found at the flowers in the spring and in the late summer and fall months.

Genus *Caupolicana*

Although a few species of this New World genus of mostly large-sized bees occur in tropical America, the largest numbers of species chiefly inhabit the warm temperate and subtropical regions of both North and South America (Michener, 1966). Most of the species have been described from Chile and only two of the five recognized subgenera, *Caupolicana,* sensu stricto, and *Zikanapis,* are known to occur in the *Larrea* regions of the southwestern United States and adjacent Mexico. Only one species of the nominate subgenus, *Caupolicana yarrowi,* has established a floral relationship with *Larrea.*

1. *Caupolicana (Caupolicana) yarrowi* (Cresson)

Caupolicana yarrowi is a large, black-banded, polylectic bee occurring from central Arizona, New Mexico, and western Texas southward through the central highlands of Mexico to Tehuacan, Puebla, Mexico (Michener, 1966). While adults are active

primarily in late summer and fall, visiting pollen and nectar sources very early in the morning and in late afternoon (Linsley and Cazier, 1970), a few specimens have been collected as early as 6 June (Huachuca Mountains, Arizona) and 23 June (Tehuacan, Mexico).

Michener (1966) has summarized the knowledge regarding the habits and flower relationships of this species as follows (bracketed material supplied by present authors):

> Cockerell (1899) records the flight of *C. yarrowi* as from [0515–0615 hours] (between dawn and sunrise) on September 4 and 5 in the Organ Mountains, New Mexico. He records a series from flowers of *Datura meteloides,* and two from *Lippia wrightii.* Probably these were nectar sources and Linsley [1960a] and Linsley and Hurd (1959) record males of *C. yarrowi* taking nectar from *Melilotus alba* and *Larrea divaricata.* At least on the latter plant the bees were active before dawn. I have also seen the species near Douglas, Arizona, at about sunrise on *Larrea,* not collecting pollen. Specimens collected at Encarnacion de Diaz, Jalisco [during the late afternoon] on *Eysenhardtia polystachya* had no pollen on the scopa and probably were feeding on nectar.
>
> Linsley and Cazier (1963) treat pollen collecting, especially on *Solanum,* in some detail, showing, for example, that in mid-August in southern Arizona on a clear morning the activity was from [0520–0650 hours] while on an overcast morning it was from [0520–0850] (sunrise both days was approximately [0600]). Most other pollen collecting bees on the same flowers started later and continued much later, but *Ptiloglossa jonesi* Timberlake, while largely synchronous with *C. yarrowi,* started work perhaps slightly earlier and under overcast conditions stopped its activities considerably earlier than *C. yarrowi.* Pollen collecting, however, is not restricted to *Solanum* and 70% of the females collecting on *Solanum* already carried some *Mentzelia*-like pollen. At the same place where it visits *Solanum* in the morning, *C. yarrowi* collects pollen in the evening [1750–1913 hours, sunset at 1851] from *Mentzelia pumila,* a flower that is not open in the morning.

Early morning sampling at Portal and Douglas, Arizona, and Granite Pass, Antelope Pass, Deming, Las Cruces, Elephant Butte, and Socorro, New Mexico, and late afternoon sampling at Portal, Douglas, and Las Cruces have shown that *Caupolicana* females visit *Larrea* morning and evening for pollen and nectar, mostly between 0500 and 0800 and 1930 and 2030. The first bees to arrive in the morning and the last in the evening often take nectar only. In southeastern Arizona, alternate pollen sources in the morning are primarily *Solanum elaeagnifolium, S. rostratum,* and *Cassia bauhinioides;* in the evening, *Mentzelia pumila* and *Datura meteloides* (Linsley and Cazier, 1963, 1970, 1972; Michener, 1966).

Males also visit *Larrea* in both the morning (Linsley and Hurd, 1959) and evening for nectar during approximately the same hours utilized by the females. They establish their territories near the lower parts of the *Larrea* plant at heights of 12–15 inches above the ground and poise facing the plants. Periodically they rise higher, and occasionally leave on fast erratic cruising flights around *Larrea* plants before returning to their territory (searching for females?). They dart immediately after both females and males which enter the territory. Those females which are grasped and released in the air (nonreceptive) will usually return to the flowers immediately. Males are sometimes quickly released or merely chased; at other times both individuals fall to the ground and tumble about for several seconds. During the evening flight, males spend most of the time in fast, erratic cruises of *Larrea* plants but pause from time to time for nectar. Males "sleep" singly, not gregariously like some other large desert bees (Linsley, 1962a).

Both males and females forage primarily on the outer and upper branches of *Larrea* blossoms. Under heavy morning overcast both sexes may initiate or extend their flight later in the day.

A related species, *Caupolicana electa* (Cresson), is a matinal and crepuscular species which visits *Trichostema dichotomum* Linn. (bastard pennyroyal) in the sand-ridge areas of the coastal plain from North Carolina to Georgia and Alabama (Mitchell, 1960); Michener (1966) cites references to at least two specimens which were collected in Dade County, southern Florida.

Genus *Ptiloglossa*

This is a chiefly Neotropical genus of large-sized bees, which occurs throughout much of the Americas except Chile (Michener, 1966). Two of the species, which presumably extend from Mexico into southern Arizona, occur at the flowers of *Larrea* in the late summer and early fall.

2. *Ptiloglossa arizonensis* Timberlake

This species was described from Portal, Arizona, at flowers of *Solanum elaeagnifolium* (Timberlake,

1946) and its pollen-collecting behavior at *S. elaeagnifolium, S. rostratum,* and *Cassia bauhiniodes* has been reported by Linsley (1962b) and Linsley and Cazier (1970). Adults are active in late summer and fall. Near Portal, Arizona, we have observed *P. arizonensis* taking pollen and nectar from *Larrea* in the early morning, mostly between 0445 and 0600, and occasionally returning for nectar in the evening (1700–1930). However, although the females frequently visit *Larrea,* since it is not a preferred host, pollen-collecting females often carry mixed or foreign loads, especially from *Solanum,* which produces little or no nectar.

Males have been taken while feeding on *Larrea* nectar in the morning but, as yet, not in the evening—nor have they been observed in territory around *Larrea* plants.

Both sexes are very fast fliers and forage on the upper and outer parts of the plant.

3. *Ptiloglossa jonesi* Timberlake

This species, like the preceding, was described originally from Portal, Arizona (Timberlake, 1946, 1965). Females have been observed taking pollen from *Solanum elaeagnifolium* and *S. rostratum* near Douglas, Arizona (Linsley and Cazier, 1963), and pollen and/or nectar from *Larrea* near Portal, Arizona, in summer and early autumn (Linsley and Cazier, 1970). However, we have found them more abundant on *Larrea* at Douglas than at Portal, where they are usually the first bees to arrive in the morning. Females appear about 45 minutes before sunrise on a clear day and disappear about sunrise. Males are most active at the flowers during this same period, but a few stragglers appear up to an hour and one-half after sunrise. Females may return for pollen and/or nectar in the evening (1800–2000) but evening flight of males has not been observed. Both sexes forage on upper and outer parts of the plant and, like *P. arizonensis,* are very rapid fliers.

Genus *Colletes*

Species of this genus, which is represented throughout much of the world except Australia, are numerous in North America (Stephen, 1954), and several of these species have established a dependent relationship upon the pollen and nectar of *Larrea.* Males characteristically patrol the *Larrea* plants, periodically pausing at the flowers for nectar. Males of the smaller species tend to hover about the plants, while those of larger species usually cruise rapidly and erratically in and about the canopy. During periods of strong winds, the males are frequently concentrated on the leeward side of the plant, where they tend to hover, occasionally landing on the flowers for nectar or attempting to mate with the females. In some species many of the females appear to seek those flowers which are either in the shade or in the less sunlit areas of the plant.

4. *Colletes clypeonitens* Swenk

FIGURE 1

This is a common spring species of the Colorado and Mojave deserts of southern California and the Sonoran Desert of Arizona and is one of the most consistent *Larrea* oligoleges. Timberlake (1951a) states that it visits *Larrea* almost exclusively, but stray specimens have been taken at flowers of *Cercidium* and *Encelia.* In the collections at Riverside (Timberlake), Berkeley, and Davis, there are more than 80 separate samples from *Larrea,* with a high proportion of females bearing *Larrea* pollen in their scopae. We have found them present at all our spring sampling sites in Arizona and southern California, usually in large numbers. Dr. G. E. Bohart also obtained it in large numbers during his sampling program at St. George, Utah, in late May (Table 15).

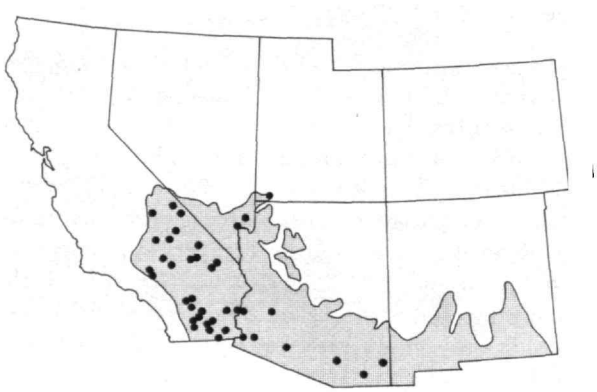

FIGURE 1.—*Colletes clypeonitens* Swenk.

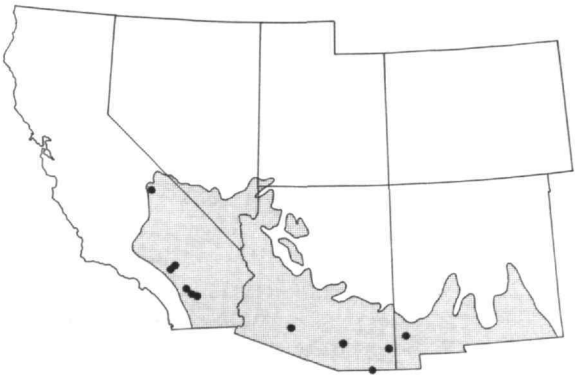

FIGURE 2.—*Colletes covilleae* Timberlake.

5. *Colletes covilleae* Timberlake

FIGURE 2

This species appears to be a *Larrea* oligolege, and all of the pollen-bearing females we have seen were carrying pollen of this plant. Its range appears to be limited largely to the Sonoran Desert of Arizona and southern California but extends on the Mojave Desert and into Baja California. Adults are active in the spring (March and April on the low deserts, May and June on the Mojave Desert and in the Owens Valley).

6. *Colletes larreae* Timberlake

This is an uncommon species having been taken on *Larrea* primarily at Palm Springs, Riverside County, California, in March and April. Timberlake records a male collected in May from *Acamptopappus sphaerocephalus* on the Mojave Desert (Lovejoy Buttes) and another male obtained from *Barbarea orthoceras* at Tetley Park in the San Bernardino Mountains, California. Stephen (1954) also records the species from Olancha, Inyo County, California, and Wellton, Arizona. In the city of Palm Springs, California, during the spring of 1974 (April) we encountered both sexes of this species at the flowers of *Larrea,* and all of the females were collecting pollen. In spite of the Tetley Park record, this species is regarded by us as an oligolege of *Larrea.* Flight records extend from 20 March to 20 May.

7. *Colletes louisae* Cockerell

This species has long been known under its more recent name *C. tucsonensis,* which has been synonymized by Stephen (1954). It ranges through the *Larrea*-belt from western Texas and adjacent northern Mexico to southern California and Baja California Norte. Timberlake (1943) reports that it is principally an autumnal species, at least in southern California where it occurs abundantly on the Mojave and Colorado deserts. However, a smaller vernal brood occurs regularly, visiting various Compositae (e.g., *Malacothrix, Geraea, Baileya, Encelia*) and desert shrubs (including *Agave, Cercidium, Prosopis,* and *Larrea*). Females carrying *Larrea* pollen have been captured sparingly in Riverside and San Bernardino counties, but this host is probably used to some extent throughout the range of the spring brood.

According to Timberlake (1943), females of the autumnal brood visit Compositae exclusively. He also reports finding males swarming in large numbers at flowers of *Ericameria* on the Mojave Desert in October. We have taken females at *Chrysothamnus* in the same general area.

8. *Colletes salicicola* Cockerell

FIGURE 3

Colletes salicicola was described from females taken at flowers of *Salix* at Las Cruces, New Mexico. The range as known at present extends from Texas (Big Bend National Park) through southern New Mexico and Arizona to southern

FIGURE 3.—*Colletes salicicola* Cockerell.

California (Stephen, 1954). The species is polylectic. The female has been collected at *Larrea, Hyptis, Eriogonum, Prosopis, Cercidium,* and *Dalea,* and flies from 17 February to 9 June (Timberlake, 1951a). Timberlake (1943) reports that this species and *C. clypeonitens* are the two commonest vernal species on the California deserts. Although it has been recorded visiting a number of desert plants by Stephen (1954), it is without doubt on the basis of our field studies a regular *Larrea* polylege.

9. *Colletes stepheni* Timberlake

This species is a rarely collected spring species thus far known only from the Colorado Desert in Riverside County, California. It is matinal in pollen-collecting activity, the foraging flights occurring primarily from just before sunrise to an hour and one-half after sunrise (0450–0620 hours in mid-April) (Hurd and Powell, 1958). Large numbers of individuals of both sexes have been taken at *Larrea* 18 miles west of Blythe, California (type-locality), and a few females at *Cercidium floridum* in the company of *Martinapis luteicornis* (Timberlake, 1958b).

An account of the nesting habits of this species in sand dunes at the site near Blythe, where the females were storing *Larrea* pollen, has been given by Hurd and Powell (1958). They record evening flights of males at the nest site involving large numbers of individuals. The flights began about an hour before sunset, reached a peak about a half-hour before sunset and diminished rapidly as they continued into the twilight period. During the night the males slept in large numbers on dead stems of Galleta grass *(Hilaria rigida),* clinging with their legs and facing head downward.

10. *Colletes wootoni* Cockerell

This is a common polylectic species, which is found upon the flowers of many different kinds of plants, and is known to occur from the southern portion of Texas, New Mexico, and into Arizona (Stephen, 1954). It is active from early March well into October and is, on the basis of our studies, a common, regular polylege of *Larrea* during both of its flowering periods.

Family ANDRENIDAE

Although on occasion some species of such genera as *Andrena, Hypomacrotera,* and *Pseudopanurgus* have been taken at the flowers of *Larrea,* our field investigations in the southwestern United States disclose that only certain species of the genera *Ancylandrena* (1 oligolege), *Megandrena* (1 oligolege), *Nomadopsis* (2 oligoleges), and *Perdita* (8 oligoleges, 2 regular polyleges) have established a regular dependency upon the pollen and nectar of *Larrea.* It is noteworthy that of the 22 species of bees which have developed an oligolectic relationship with *Larrea* about 50 percent (12 species) are members of this family. Most of these (8 species) belong to the genus *Perdita,* and it seems entirely possible that some additional species of that genus will be found upon further investigation to be oligoleges of *Larrea.*

It is significant that while there are no known species of *Andrena* oligolectic on *Larrea,* two presumably closely related genera, *Ancylandrena* and *Megandrena,* each contain an oligolectic species on *Larrea.*

Genus *Ancylandrena*

Included in this genus, which occurs in the southwestern United States (Arizona, California, and Nevada) and northern Mexico, are four vernal species (Zavortink, 1974). Our intensive field studies confirm that one of these species, *Ancylandrena larreae,* is an oligolege of *Larrea.* As is detailed in the species account which follows, *A. larreae* is now known to occur as far east as Lordsburg, New Mexico.

1. *Ancylandrena larreae* Timberlake

FIGURE 4

This is a *Larrea* oligolege of the Colorado and Mojave deserts of southern California, ranging from San Diego and Imperial counties to the Owens Valley and east to Lordsburg, New Mexico. It is a spring species, with the principal flight in March and April in the lower deserts, May in the higher areas.

Zavortink (1974), in his revision of the genus *Ancylandrena,* describes this species fully, figures its critical characters, and maps its distribution as

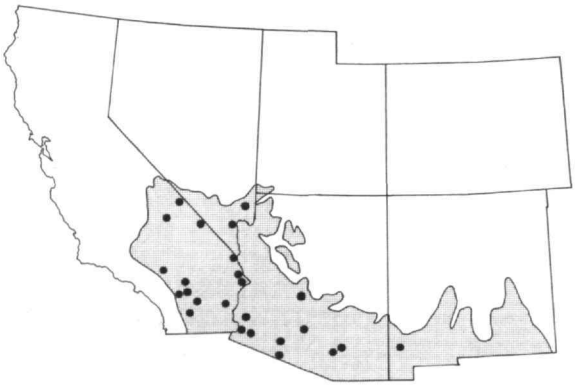

FIGURE 4.—*Ancylandrena larreae* Timberlake.

known to him. He regards it as oligolectic on *Larrea,* and states that all but two of the 58 males and 80 females examined by him (which bore flowers records) were from this plant, the exceptions being single males taken on *Dalea greggii* and *Prosopis juliflora.* He reported that the species was abundant during April 1969 in the Chemehuevi Valley west of Havasu Lake, California. On 21 April individuals were common on *Larrea tridentata* during the 1.5 hours following sunrise, less abundant from 1.5 to 4.5 hours after sunrise, absent from 4.5 to 5.5 hours after sunrise, and rare during the half hour preceding sunset. No attempt was made to collect at this site before sunrise, during the late morning, or during the afternoon, and it is not known if *A. larreae* was active at these times. Zavortink summarized the distribution as known to him as the deserts of southern California, southern Nevada, and Arizona. We have incorporated the localities recorded by him in our map (Figure 4) and have added localities from our surveys. The most significant of these is Lordsburg, New Mexico, where a male was taken between 0445 and 0600 on 25 May 1973 by Juanita M. (Mrs. E. G.) Linsley. This collection extends the range from the Mojave and Sonoran deserts well into the Chihuahuan Desert, just west of the Continental Divide.

We encountered *A. larreae* at most of our March and April *Larrea* sample sites in California and Arizona. However, it was most abundant in Palm Springs, Riverside County, California, in early April. Half-hour samples yielded 229 pollen-collecting females, two nectar-drinking females, and 68 males. The females first appeared at the *Larrea* flowers at sunrise or shortly afterward (air temperature 16° C) and reached a peak in numbers about mid-morning (Table 13). A few scattered individuals (19) were captured while taking pollen between 0930 and 1429. The peak of male activity about *Larrea* flowers coincided fairly well with that of females, as judged from our samples, and only four examples were taken between 0930 and 1429.

When the females first begin to collect pollen as the sun rises, they work the flowers on the outside of the plant on the side exposed to the sun. As the temperature rises, they move inside the plant and onto the shady side. Their flight also becomes faster, assumes a zigzag pattern, and they move a considerable distance between flowers, sometimes visiting but a single flower on a plant. Males, when they first appear, drink nectar and remain on the flower for up to half a minute. They then assume a fast, irregular cruising flight about the plants, pausing only occasionally, and then briefly, for nectar. No "mating" encounters were observed.

Genus *Megandrena*

Like *Ancylandrena,* this genus is restricted to the southwestern United States and adjacent northern Mexico.

2. *Megandrena enceliae* Cockerell

This species was originally described from two males collected from flowers of *Encelia farinosa* (Compositae) from near Salt Creek (Salton Creek, Riverside County), California, by P. H. Timberlake (Cockerell, 1927). We have found it to be a rather widespread *Larrea*-visiting species in the Sonoran Desert of southern California and Arizona, primarily flying in March and April. We have seen males and females (without pollen) from west of Stanfield, Pinal County, Arizona, taken on 11 April 1955 by Butler and Werner, and in the *Larrea* bee surveys of 1972 G. E. Bohart found the species at the Silverbell IBP study area northwest of Tucson, Pima County, Arizona, Picacho State Park, Pinal County, Arizona, Gila Bend, Maricopa County, Arizona, and 22 miles south of Salome, Yuma County, Arizona. He found females gathering *Larrea* pollen at both Silverbell and Salome. At the latter locality he observed females taking pollen over a 12-hour period, from 0700 to 1900, just before sunset (Table

14). The principal pollinators associated with *Megandrena* at this site were *Ancylandrena larreae, Heteranthidium larreae, Colletes salicicola,* and *C. clypeonitens,* although other bees were present in smaller numbers.

In the spring of 1952 (April) at Hopkins Well, 18 miles west of Blythe, California, hundreds of males were found in the partially closed flowers of *Geraea canescens,* following the appearance of an early afternoon light rain, which persisted off and on well into the night. The bees were still present in these flowers early the next morning, but as the sky cleared and as the temperature rose during the morning, they resumed flight about the *Larrea* plants, where they were frequently observed sipping nectar and attempting to mate or mating with the females.

Genus *Perdita*

This genus of usually very small-sized bees contains several hundred species and occurs transcontinentally in the United States, ranging from Canada into northern Central America. The genus is especially well represented by large numbers of species in the arid regions of the southwestern United States, and not unexpectedly a number of these species have been found by us and others at the flowers of *Larrea.* While several species of the eight known *Larrea* oligoleges are often present at the flowers in large numbers, they are usually unevenly distributed at the flowers and tend to "swarm" about one or two branches on the leeward side of the plant if there is a breeze or on the shady side if the air is still.

Females of a number of species of *Perdita* believed to be oligoleges of other plants have been taken at least once at the flowers of *Larrea.* Among these are the following species, many of which belong to the nominate subgenus: *P. dentata* Timberlake, *P. erythropyga* Timberlake, *P. eucnides platyzona* Timberlake, *P. exclamans* Cockerell, *P. eximia* Timberlake, *P. fulvicauda* Timberlake, *P. genalis panamintensis* Timberlake, *P. mohavensis* Timberlake, *P. mortuaria* Timberlake, *P. numerata hesperia* Timberlake, *P. ovaliceps* Timberlake, and *P. turgiceps* Timberlake.

Much remains to be learned about the behavior and intrafloral ecology of *Perdita* on *Larrea.*

3. *Perdita (Perdita) flavipes* Timberlake

This species is a member of the Sphaeralceae group (Eximia subgroup) and is considered by Timberlake (1964) to be one of the rarer bees of the Colorado and Mojave deserts. He has recorded specimens from Edom (Thousand Palms) and Indio in Riverside County, Furnace Creek, and Stovepipe Wells in Death Valley and south of Palacio, Baja California. Most of the known examples were taken at *Larrea,* and some of the females were carrying *Larrea* pollen. The species flies in March and April.

4. *Perdita (Perdita) covilleae* Timberlake

FIGURE 5

This member of the Sphaeralceae group (Zebrata subgroup) is a common bee visitor to *Larrea* in the Colorado and Mojave Desert areas of southern California and has been taken also in Nevada, Arizona, and Baja California (Timberlake, 1958a). Females take pollen from *Larrea,* flying from late March to early May on the Colorado Desert, in May and June in the Owens Valley, and late May in St. George, Utah (Table 15).

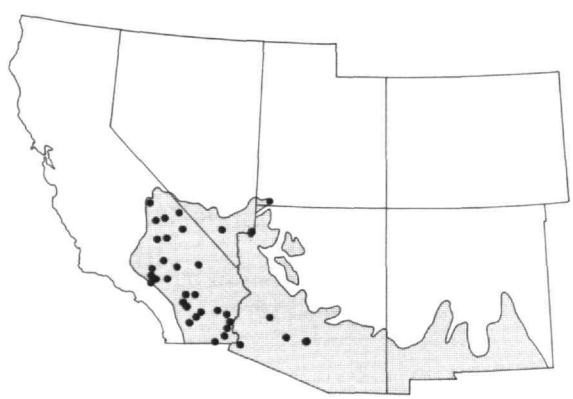

FIGURE 5.—*Perdita covilleae* Timberlake.

5. *Perdita (Perdita) punctulata* Timberlake

FIGURE 6

This is the most abundant vernal species of *Larrea*-visiting *Perdita* in the southern California deserts. It also occurs in Arizona and northern Mexico (Baja California and Sonora). Females ac-

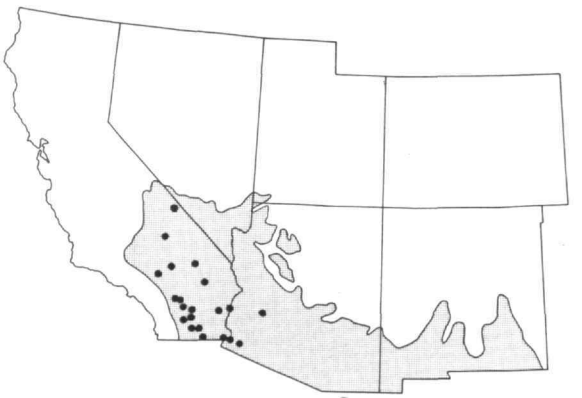

FIGURE 6.—*Perdita punctulata* Timberlake.

tively gather *Larrea* pollen but both sexes also visit *Prosopis*. Timberlake (1958a) provides detailed collection data from a wide range of localities from Imperial and San Diego counties to Death Valley, the northern Mojave Desert and the Owens Valley. It belongs to the Sphaeralceae group and like the preceding species is a member of the Zebrata subgroup.

6. *Perdita (Perdita) semicaerulea* Cockerell

This species, which is a member of the Sphaeralceae group, is the only representative included in the Semicaerulea subgroup. Described originally from *Larrea* flowers at San Marcial, Socorro County, New Mexico, it has since been collected at various localities from Terrell County, Texas, through New Mexico to Arizona and northern Mexico (Timberlake, 1964). Collection records for females are almost exclusively from *Larrea*. Flight activity involves both the spring and autumn blooming period of *Larrea* in regions characterized by both winter and summer rainfall. This was by far the most abundant species of *Perdita* encountered by us in southeastern Arizona in both the spring and fall.

7. *Perdita (Perdita) eremica* Timberlake

Perdita eremica is assigned by Timberlake (1964) to the Sonorensis subgroup of the Sphaeralceae group. Five other desert species mostly found at flowers of *Prosopis* are also included in this subgroup. Although females of *P. eremica* gather pollen from *Larrea*, they have also been taken on several occasions by Timberlake at flowers of *Dalea schottii* on both the Mojave and Colorado deserts. The species flies in late March, April, and early May.

8. *Perdita (Perdita) luciae decora* Timberlake

Perdita luciae belongs to a group of species (Exclamans subgroup, Sphaeralceae group), most of which, according to Timberlake (1964), visit amentaceous flowers of *Prosopis*, and *Salix*. *P. luciae* also visits *Prosopis*, but females have been collected from *Larrea* by Timberlake, us, and others. The species ranges from New Mexico and Arizona into southern California and northern Mexico and is active in the spring (Timberlake, 1964).

9. *Perdita (Perdita) lateralis lateralis* Timberlake

Timberlake (1962) regards this as one of the rarer desert *Perdita* and states that it has never been taken in numbers. His records include various localities in the Sonoran Desert of southern California and Arizona. Most of the known females have been captured at *Larrea* flowers. It belongs to the Ventralis section of the Ventralis group. The flight season of this species is March and April.

10. *Perdita (Perditella) larreae* Cockerell

FIGURE 7

This and the following species belong to the small subgenus *Perditella*. Both are *Larrea* bees

FIGURE 7.—*Perdita larreae* Cockerell.

but their two relatives, *P. (P). cladothricis* Cockerell and *P. (P.) minima* Timberlake, visit *Tidestromia* and *Euphorbia,* respectively.

Perdita larreae was described originally from San Marcial, New Mexico, from the flowers of *Larrea.* Its range is now known to extend westward through Arizona to southern California and northern Mexico (Timberlake, 1956). Females fly primarily in the late summer and autumn, but there is a spring flight in the Sonoran Desert of Arizona and southeastern California. We found it abundant in the San Simon Valley of Arizona and New Mexico.

11. *Perdita (Perditella) marcialis* Cockerell

This species, like the preceding, was originally collected from *Larrea* flowers at San Marcial, New Mexico. It ranges from western Texas into Nevada, southern California, and Mexico (Sonora; Coahuila) (Timberlake, 1956). Females fly primarily in September, gathering pollen from *Larrea* during the second bloom, which follows the summer rains in the eastern portion of its range. However, Timberlake (in litt.) does not regard this species as an oligolege of *Larrea* because the females have been collected at the flowers of a wide variety of other plants.

12. *Perdita (Pseudomacrotera) turgiceps* Timberlake

This species, assigned to the monotypic subgenus *Pseudomacrotera,* is remarkable for the enormous head of the male. Although primarily confined to the Colorado Desert of southern California, it extends into the Mojave Desert and Owens Valley to the north and into Baja California Norte to the south and Arizona to the east. Timberlake (1954) provides collection data containing flower records, of which *Larrea* appears to be the most common host for females. Flight periods are primarily April and May in the Colorado Desert, extending into June in the Owens Valley. We found this species commonly about the flowers of *Larrea* in some parts of the city of Palm Springs, California, during early April of 1974.

Genus *Nomadopsis*

This genus, which contains more than 30 species, occurs over much of the western United States and adjacent to northern Mexico. Like the genus *Perdita,* to which this genus bears a somewhat similar appearance, many of its species are oligolectic in their pollen-collecting habits. Only two species of the genus *Nomadopsis* have been found at the flowers of *Larrea,* and both of these are oligolectic on the pollen of that plant. These oligoleges belong to the subgenus *Micronomadopsis* and are encountered only in the desert areas of southern California. Neither of them has been observed in large numbers and both tend to be highly localized in occurrence.

13. *Nomadopsis (Micronomadopsis) foleyi* Timberlake

Nomadopsis foleyi collects pollen from *Larrea* in the Mojave and Colorado Desert areas of California, flying in April (Timberlake, 1952; Rozen, 1958).

14. *Nomadopsis (Micronomadopsis) larreae* Timberlake

FIGURE 8

This species was described from females collected from flowers of *Larrea* at Edom (Thousand Palms), Riverside County, California (Timberlake, 1952), and appears to be a *Larrea* oligolege. It is a spring species, as would be expected, flying from late March to early May. At present, it is known only from the Mojave and Colorado deserts of southern California. Rozen (1958) has reported on several

FIGURE 8.—*Nomadopsis larreae* Timberlake.

aspects of the life history, emphasizing an apparent correlation between the distribution of the species and sand dunes. As with many *Larrea* oligoleges it nests in sandy soil.

Family OXAEIDAE

This is strictly a New World family of rather large-sized Neotropical bees. It contains only two genera, *Oxaea* and *Protoxaea,* both of which occur in South America (Moure, 1944), but only *Protoxaea* is represented in North America where it ranges into the southwestern United States.

Genus *Protoxaea*

Of the three species of this chiefly Neotropical genus, which occur in the southwestern United States, only the following species has been found at the flowers of *Larrea,* emerging in time for the second period of bloom.

1. *Protoxaea gloriosa* (Fox)

Adults of this species are active in late summer and fall. Females visit *Larrea* for pollen primarily in the morning, the principal period of activity being between 0730 and 0930 (1.5–3.5 hours after sunrise). Before, after, and during this time, some females visit the flowers for nectar only. Also near midday, nesting, pollen-storing females return to *Larrea* for nectar only. The periodicity of nectar flights relates to burrow activity and the necessity, in this species, for storing large quantities of nectar, in addition to pollen, in the cells. During midday nectar flights, females move very rapidly from plant to plant, rarely visiting more than one or two flowers on an individual, although poising very briefly in front of several others (rejecting because of lack of nectar?). Alternate pollen sources for this species are primarily *Solanum elaeagnifolium, S. rostratum, Cassia bauhiniodes, Calliandra schottii,* and *Kallstroemia grandiflora* (Linsley and Cazier, 1972).

Males of this species visit *Larrea* for nectar in the morning (0800–1000) when their massed sleeping aggregations break up, from time to time during the day while maintaining territories (1100–1400), and again before aggregating for the night (1530–1700). When in territory in front of or between two *Larrea* plants, they face away from plant, darting out to chase or strike any flying object that comes within range (quite similar to the behavior of males of *Caupolicana*). Under heavy overcast skies, females start collecting pollen later in the day and continue to do so beyond the usual period when the sun is bright.

Both sexes, when foraging, primarily visit the upper and outer portions of the *Larrea* plant, a behavior that greatly facilitates collecting but which also permits the bee an opportunity for rapid escape, if disturbed. Our *Larrea* samples are from a number of localities in southern Arizona, New Mexico, and Sonora.

Family HALICTIDAE

While certain species of six genera (*Agapostemon, Dialictus, Evylaeus, Halictus, Lasioglossum,* and *Nomia*) of this nearly cosmopolitan family have been found with sufficient regularity at the flowers of *Larrea* to be included in this study, we and others have not unexpectedly encountered on occasion at the flowers a few specimens of other species representing such genera as *Dufourea* and *Sphecodes.*

Based upon our field investigations, there are no species of this family which are oligoleges of *Larrea,* nor is there any evidence in literature to suggest such a relationship. Nevertheless, our field investigations have established that there are at least 17 species associated with the flowers of *Larrea* either as regular polyleges (4 species) or as casual polyleges (13 species). Most of these species (15) are present at the flowers during both the spring and late summer blooming periods. So far as we have been able to determine, a single species of this family is present only during the spring bloom (*Dialictus hudsoniellus*) and similarly only one species is mainly present during the late summer and fall bloom (*Nomia tetrazonata*), although its flight period is known to extend from early March into October. Of the 17 species of halictids which exhibit some dependency upon the nectar and pollen of *Larrea,* 8 are described species of the genus *Dialictus* and 4 are *Agapostemon.* Since there are several additional, but undescribed species of *Dialictus* and *Evylaeus* collected by us and others at the flowers of *Larrea,* we anticipate that further studies both in the field and in the laboratory will

increase the number of known halictid species regularly and casually dependent upon *Larrea.*

Genus *Halictus*

Although our investigations reveal that five species (*H. farinosus, H. ligatus, H. parallelus, H. rubicundus,* and *H. tripartitus*) of this mainly Holarctic genus visit the flowers of *Larrea,* only *Halictus farinosus* has established a sufficient dependence (casual polylege) to be included in this study. The other species have only on occasion been observed by us at the flowers, which tends to confirm the paucity of *Larrea* floral records for these species in the collections made by us and others during previous field work in the southwestern United States.

1. *Halictus (Halictus) farinosus* Smith

Halictus farinosus is one of the most abundant species of the genus in western North America, ranging from Nebraska, Montana, and British Columbia south to New Mexico and California. It is a highly polylectic species, gathering pollen from a wide range of plants in a broad spectrum of environments. Females are active in the spring, summer, and fall. They take pollen from *Larrea* primarily on the desert periphery.

Genus *Lasioglossum*

In our field investigation we have found only one species of this widely distributed genus at the flowers of *Larrea.*

2. *Lasioglossum sisymbrii* (Cockerell)

This is a widespread polylectic species occurring from Wyoming and British Columbia to New Mexico, Arizona, California, Sonora, and Baja California. In the desert areas of southwestern United States, the females visit a wide variety of spring annuals of several families. They are active throughout the day and have been taken before and after sunrise at morning-flowering species of *Camissonia* (Onagraceae) in California and Nevada and near sunset on late-afternoon blooming species of the same genus (Linsley, MacSwain, and Raven, 1963a, 1963b). We have captured females taking pollen from *Larrea* at a number of localities in the southwestern United States, including Death Valley.

A nonnesting female was observed "sleeping" on dry stems of *Heterotheca* near individuals of *Agapostemon* and *Stenodynerus* near Portal, Arizona, in June (Linsley, 1962a). We have also taken them at *Mentzelia* and other summer- and fall-blooming plants in southeastern Arizona in July, August, and September.

Genus *Evylaeus*

Although our field studies have revealed that several species of this genus are on occasion to be found at the flowers of *Larrea,* only the following species is sufficiently dependent upon its pollen and nectar to be included in this study.

3. *Evylaeus amicus* (Cockerell)

Evylaeus amicus was named originally from females captured in the Mesilla Valley, New Mexico, at flowers of *Sisymbrium* (Cockerell, 1897a). The species is polylectic, visiting many kinds of plants for pollen, including *Larrea,* in that portion of its range that includes the deserts. In southern California, females have been taken from *Larrea* flowers near Edom (Thousand Palms), Riverside County, in February and April and 30 miles west of El Centro, Imperial County in February (P. H. Timberlake).

Genus *Dialictus*

At nearly every site we have found members of this genus, sometimes in large numbers and representing several species, flying over or hovering about the canopy of *Larrea.* Frequently both the males and females visit the flowers for nectar and commonly the females have been observed collecting pollen. In our sampling program we obtained 602 specimens (545 females and 57 males) representing at least 12 species, several of which apparently are undescribed. Doubtless some additional species may be expected to occur at the flowers of *Larrea* with sufficient regularity to be classed as *Larrea* bees. With the exception of *Dialictus pruinosiformis,* which is a regular polylege of

Larrea, all the other species we have studied, including some of the apparently undescribed species, are casual polyleges based on their intrafloral relationships with *Larrea.*

4. *Dialictus alius* (Sandhouse)

Sandhouse (1924) named this species from the females, captured at flowers of *Nuttallia multiflora* at La Cueva, Organ Mountains. We captured a single female each on *Larrea,* one mile north of Portal, Naco, and four miles west of Don Luis, Cochise County, Arizona, two females at Douglas, and a male and female at Tombstone, Cochise County, Arizona. These few records were scattered throughout the morning (0630–1200), and the dates were in May and June.

5. *Dialictus clarissimus* (Ellis)

This species was originally named from one female collected from flowers of *Malvastrum* at Eddy, New Mexico, in April (Ellis, 1914c). We obtained a single female at the flowers of *Larrea* at Douglas, Cochise County, Arizona, between 0800 and 0829 on 18 July 1973.

6. *Dialictus clematisellus* (Cockerell)

Cockerell (1904a) described this species from females taken at Pecos, New Mexico, in July. He noted that it occurred in numbers at flowers of *Clematis ligusticifolia,* but that it had been found on no other plant. However, he subsequently (Cockerell, 1904b) recorded both sexes as common at flowers of *Petalostemon oligophyllus.* It is now known to be a widespread polylectic species, primarily confined to the southwestern deserts from New Mexico to southern California. We captured four females at *Larrea* flowers and three females 1 mile north of Portal and one at Douglas, Cochise County, Arizona, during May, June, and July. The captures were scattered throughout the day (0830–1430).

7. *Dialictus hudsoniellus* (Cockerell)

Described from Longs Peak Trail, Rocky Mountain National Park, Colorado, at an elevation of approximately 10,500 ft. We captured four females at flowers of *Larrea,* three at Douglas (1130–1230), and one near Portal, Cochise County, Arizona. The dates were in May and June.

8. *Dialictus hyalinus* (Crawford)

Dialictus hyalinus was originally described from Ormsby County, Nevada (Crawford, 1907). It is a western species ranging from Washington to Utah, southern California, and Arizona. Although polylectic and visiting a wide range of plants for pollen, including Onagraceae (Linsley, MacSwain, and Raven, 1963a), females have been taken in several desert localities while gathering pollen from *Larrea* along with other desert shrubs and annuals. *Larrea* collections have been mostly made in February, March, and April.

9. *Dialictus microlepoides* (Ellis)

This species was described from a female captured at flowers of *Datura meteloides* at La Cueva, in the Organ Mountains, New Mexico, altitude 5300 ft (Ellis, 1914b). It is now known from most of the desert areas of southwestern United States and northern Mexico, but its range extends beyond the region. We took 25 females and 5 males on *Larrea* flowers at Las Cruces, Dona Ana County, New Mexico, Lordsburg and Granite Pass, Hidalgo County, New Mexico, 1 mile north of Portal, Douglas, Tombstone, Naco, Benson, and 4 miles west of Don Luis, Cochise County, Arizona, and 18 miles west of Tucson, Pima County, Arizona. It was present in the spring and fall and flew throughout the day (0730–1530).

10. *Dialictus perparvum* (Ellis)

Dialictus perparvum was first named from a female captured at Phoenix, Arizona (Ellis, 1914a). We captured 126 females and 4 males at flowers of *Larrea* but have been unable to find references to its habits or distribution. Our examples from *Larrea* were taken at Lordsburg and Granite Pass, New Mexico, 3 and 6 miles north of Portal, Douglas, and Naco, Cochise County, Arizona, and Tucson, Pima County, Arizona. They were present both in the spring and fall and flew throughout the day (0730–1600).

11. *Dialictus pruinosiformis* (Crawford)

This is a widespread polylectic species occurring from Alberta, Nebraska, and South Dakota to Texas, New Mexico, Arizona, and southern California. It was by far the most abundant species of *Dialictus* encountered by us at flowers of *Larrea*. We captured 184 females and 181 males in May and June at the following localities: Lordsburg, Granite Pass, and 17 miles north of Rodeo, Hidalgo County, New Mexico; 1 and 6 miles north of Portal, Douglas, Tombstone, Naco and Benson, Cochise County, Arizona, and Tucson, Pima County, Arizona. Examples were taken throughout the day (0630–1830). In summer and fall we have also taken this species from *Larrea* from some of these same localities but in relatively small numbers.

Genus *Agapostemon*

Four species of this New World genus of bees visit the flowers of *Larrea*. Each of these species has established the role of a casual polylege with *Larrea* and tends to collect pollen primarily in the early morning around sunrise and in the late afternoon toward sunset. Occasionally at some localities significant numbers of individuals are present at the flowers, especially when other pollen sources are scarce or absent.

12. *Agapostemon angelicus* Cockerell

This is a widespread species in western North America, but, according to Roberts (1972), it is common only in the arid regions of the southwestern United States and northern Mexico. The female is polylectic like other members of the genus, but we have records of small numbers of both sexes from *Larrea* flowers in southeastern Arizona. Females are active in spring, summer, and fall and fly early and late in the day. They have been reported gathering pollen before sunrise from *Cucurbita foetidissima* (Linsley, 1960a) and before and after sunset from *Mentzelia pumila* (Loasaceae) in New Mexico (Linsley and Hurd, 1959) and *Camissonia and Oenothera* (Onagraceae) on the Colorado and Mojave deserts (Linsley, MacSwain, and Raven, 1963a, 1964; Linsley, MacSwain, Raven, and Thorp, 1973). Various aspects of the biology are discussed by Roberts (1969).

Males sleep gregariously in a horizontal position on dry flower heads of *Heterotheca* and other plants, tending to return to the same individual plant night after night (Linsley, 1962a).

13. *Agapostemon cockerelli* Crawford

FIGURE 9

Agapostemon cockerelli is also a polylectic bee, particularly abundant in southeastern Arizona, western Texas, and the Mexican Plateau. The known range actually extends as far north as Pat Creek, Park County, Wyoming, as far west as Wickenburg, Maricopa County, Arizona (Roberts, 1972). Roberts reports the species most abundant at elevations of 4,500–7,500 ft. He records collections of females from March through October (males, April through November) in the United States; in Mexico, June through October (males, April through December).

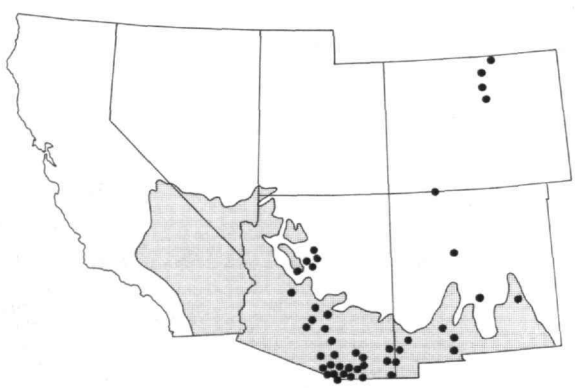

FIGURE 9.—*Agapostemon cockerelli* Crawford.

Females are active early and late in the day, reported at flowers of *Cucurbita, Oenothera,* and *Camissonia* in the early morning (Linsley, 1960a; Linsley, MacSwain, and Raven, 1963b) and at *Mentzelia* and *Camissonia* in the late afternoon (Linsley and Hurd, 1959; Linsley, MacSwain, and Raven, 1963b). We have taken both sexes at *Larrea* flowers in southeastern Arizona in August and September.

14. *Agapostemon melliventris* Cresson

This is a widespread polylectic species in western

North America (Roberts, 1972), occurring primarily in the Great Basin and desert areas of the southwestern states and northern Mexico and flying in the spring, summer, and fall. Females are active early and late in the day, reported gathering pollen before and after sunrise from *Cucurbita* and *Datura* (0456–0632) in New Mexico (Linsley, 1960a) and from *Camissonia* in the early morning and late afternoon in Nevada and in southeastern California (Linsley, MacSwain, and Raven, 1963a, 1963b). They have been captured while gathering *Larrea* pollen in a wide range of localities, both in the spring and fall blooming periods. However, this is not a preferred host and *Larrea*-visiting individuals are frequently carrying pollen from other sources.

15. *Agapostemon tyleri* Cockerell

FIGURE 10

This species is more restricted in its distribution than *A. melliventris*. Maps by Roberts (1972) indicate that the two are sympatric primarily in the eastern part of the range of that species. Like *A. melliventris*, *Larrea*-visiting females observed by us frequently have been carrying pollen from other sources on the legs, although individuals with pure loads of *Larrea* pollen have been taken. Our examples from *Larrea* were captured in late summer and fall.

Genus *Nomia*

Of the several species of this genus that occur in the southwestern United States where *Larrea* is present, only two species, both members of the subgenus *Paranomina*, regularly visit the flowers for pollen and nectar. One of these, *Nomia mesillensis*, is the principal *Larrea*-visiting species found by us at localities in the Chihuahuan Desert, while the other species, *Nomia tetrazonata*, has been found by us to be the principal species of *Nomia* at Sonoran Desert sites, especially those in the Tucson Basin. Only one other species of the genus, *N. angustitibialis*, was obtained by us during our sampling program. This was a single pollen-collecting female taken at 1 mile north of Portal, Arizona, during the spring bloom of *Larrea* (23 May 1973).

16. *Nomia (Paranomina) mesillensis* Cockerell

FIGURE 11

Nomia mesillensis ranges from southern Colorado westward to Arizona and southward to Jalisco, Mexico (Ribble, 1965 as *N. foxii*, see Hurd and Linsley, 1974). The species is polylectic. Linsley and Cazier (1963) recorded females taking pollen from *Solanum elaeagnifolium*. Ribble (as *Nomia foxii*) summarized flower visits for 191 females, 112 of which were Leguminosae (more than half of these from introduced *Medicago* and *Melilotus*), 23 from *Asclepias*, 22 from *Cleome*, and 16 from Compositae (mostly summer and fall species). He records four females and eight males from *Larrea* based upon six collections.

In southeastern Arizona we have encountered the males abundantly on *Asclepias subverticillata*, *Baccharis glutinosa*, *Koeberlinia spinosa*, and *Eriogo-*

FIGURE 10.—*Agapostemon tyleri* Cockerell.

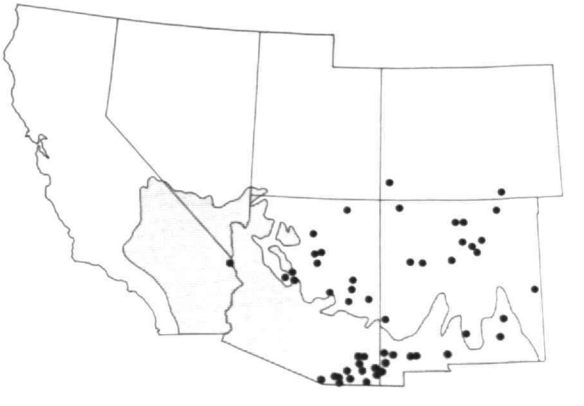

FIGURE 11.—*Nomia mesillensis* Cockerell.

num spp. They congregate in large ball-like masses in the late afternoon to form "sleeping aggregations" (Evans and Linsley, 1960). They are preyed upon by the robber flies *Mallophora bromleyi* and *Blepharepium secabilis* (Linsley, 1960b) (these two references listed as *N. tetrazonata*).

Ribble (1965) gives the earliest and latest collecting dates for this species as 15 June and 24 August, respectively.

In the San Simon Valley, females appear on *Larrea* flowers about three hours after sunrise, and their numbers taper off at about 1600. They are most abundant near midday between about 1030 and 1400, usually foraging low on the plant and often inside. Unlike their competitors, their pollen-collecting activity peaks between 1200 and 1400. They are intolerant of other females and when two or more foraging individuals come within sight of each other, they leave the flowers and chase one another around the plant until one or the other, usually the more recent intruder, leaves. No antagonism was noted toward other species of bees, large or small.

17. *Nomia (Paranomina) tetrazonata tetrazonata* Cockerell

FIGURE 12

Nomia t. tetrazonata, described originally from Globe, Arizona, ranges from southeastern California and Nevada to central New Mexico and southward to Baja California and Sonora (Ribble, 1965). The subspecies is polylectic, and Ribble records 148 females from 45 species of plants representing 41 genera. Twelve of these females and nine males were reported from *Larrea.* Females have been taken from *Larrea* flowers at Pichaco Pass, Pinal County, Arizona, in August (Timberlake, Dickson, and Swisher). Ribble records collection dates of 25 March to 28 September. In all-day samples at Tucson, Arizona, this was the dominant species visiting *Larrea.* Of 896 bees in the collection, 600 were *N. t. tetrazonata.* Of these, 596 were females, of which 391 were taking pollen.

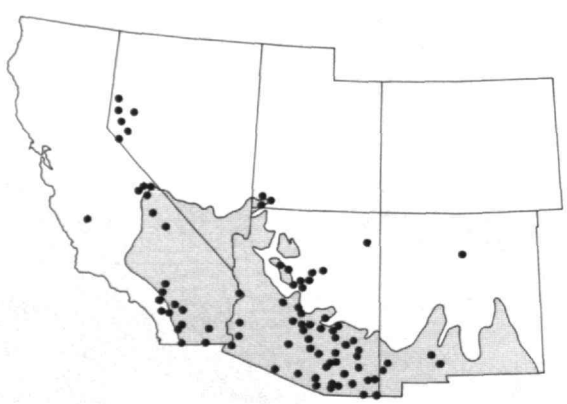

FIGURE 12.—*Nomia tetrazonata tetrazonata* Cockerell.

Family MELITTIDAE

This family is represented by three genera (*Hesperapis, Macropis, and Melitta*) in North America. Although on one occasion a female of *Melitta wilmattae* Cockerell was encountered at the flowers of *Larrea* (17 miles west of Westmoreland, California), only two species of the genus *Hesperapis* are regularly found at the flowers of *Larrea.* Both of these species are apparently oligoleges of *Larrea* and are present only during the spring bloom of that plant. The genus *Hesperapis,* as currently understood, consists of some twenty or more species, most of which have evolved as oligoleges of different plants, both annuals and perennials, especially in the more arid areas of the western United States and adjacent northern Mexico.

Genus *Hesperapis*

Of the three currently recognized subgenera of this genus, only a single species in two of these subgenera (*Hesperapis* and *Panurgomia*) has evolved a regular intrafloral relationship with *Larrea.* Based upon our investigations in both the field and laboratory, it appears that these species are *Larrea* oligoleges. While at our study sites, we most frequently encountered individuals usually in very localized settings within a particular site and then usually only a few specimens at a time; on occasion numerous specimens were obtained from a single *Larrea* plant. This is especially true of the males which sometimes literally swarm about the canopy of certain *Larrea* plants.

1. *Hesperapis (Hesperapis) arida* Michener

Hesperapis arida was described from numerous

individuals taken on *Larrea* 20 miles south of Twenty Nine Palms, San Bernardino County, California (Michener, 1936). It appears to be a *Larrea* oligolege (Stage, 1966). We have seen specimens from Victorville, Mojave Desert (May), and from several localities on the Colorado Desert (March and April), mostly in the collection of P. H. Timberlake, and mostly from the vicinity of Palm Springs, Riverside County, California. All were taken from *Larrea* and all of the females appear to be carrying *Larrea* pollen, with the exception of three individuals of each sex captured by Timberlake on *Dalea saundersii,* 3 miles southwest of Victorville on 12 May 1939. However, the pollen carried by these females has not been examined microscopically.

Stage (1966) cites *Larrea* records from Gila Bend, Maricopa County, and west of Stanfield, Pinal County, Arizona.

2. *Hesperapis (Panurgomia) larreae* Cockerell

FIGURE 13

This species appears to be a *Larrea* oligolege, ranging through the desert areas from southern California and Baja California on the west to the Big Bend area of Texas and south to Chihuahua, Mexico (Stage, 1966). Most of the examples that we have seen have been taken from *Larrea* except three females collected on *Dalea,* and these had pollen in their scopae. Judging from material in the Timberlake collection, it is a widely distributed vernal species on the Colorado Desert of California, and to a lesser extent on the Mojave Desert and in the Owens Valley, in April, May, and June. However, males were collected at the flowers of *Larrea* on 9 September 1961 by P. H. Timberlake in the vicinity of Three Rivers, Otero County, New Mexico.

FIGURE 13.—*Hesperapis larreae* Cockerell.

During our field-sampling program we obtained a total of 565 specimens of this species (372 males and 193 pollen-collecting females) from New Mexico to Palm Springs, California. On this basis it is one of the commonest pollen-collecting species of bees that visits the flowers of *Larrea.*

Family MEGACHILIDAE

While our studies of this nearly cosmopolitan family have revealed that certain pollen-collecting species of eight genera (*Anthidiellum, Anthidium Ashmeadiella, Chalicodoma, Heteranthidium, Hoplitis, Megachile,* and *Osmia*) are found with sufficient regularity at the flowers of *Larrea* to be included in this study, it should be noted that we and others have not unexpectedly taken a few specimens of other species at the flowers representing such genera as *Anthocopa* and *Proteriades.* Of the 21 pollen-collecting species regularly associated with *Larrea* in the southwestern United States, only two of these (*Heteranthidium larreae* and *Hoplitis biscutellae*) are oligoleges, and both are active only during the spring bloom of that plant. The other 19 species are either regular polyleges (7 species) or casual polyleges (12 species). About half of these species (5 regular polyleges and 5 casual polyleges) are present only during the spring bloom, while all but one of the other half (2 regular polyleges and 6 casual polyleges) are present during both the spring and late-summer blooming periods. It is noteworthy that but a single species, *Chalicodoma spinotulata,* is present only during the second flowering period. While the genera *Anthidiellum, Ashmeadiella, Heteranthidium,* and *Hoplitis* are each represented by a single species, all of which are present only during the spring bloom of *Larrea* (2 oligoleges, 1 regular polylege, and 1 casual polylege), the other four genera (*Anthidium, Chalicodoma, Megachile,* and *Osmia*) contain three or more species, some of which visit the flowers only during the spring (e.g., all species of *Osmia* and certain species of *Anthidium*) or during both flowering periods (e.g., certain species of *Chalicodoma* and *Megachile*).

Although we have taken several species of *Coelioxys* in our sampling program, we have not observed any other parasitic bees of this family at the flowers of *Larrea*. It is interesting that while *Dianthidium pudicum pudicum* (Cresson) is reported by Clement (1974) to build its nest on the branches of *Larrea*, apparently using *Larrea* resin, neither we nor anyone else has found species of that genus to visit its flowers.

Genus *Heteranthidium*

This genus, which occurs transcontinentally in the United States, contains nine species only one of which, *Heteranthidium larreae*, is found at the flowers of *Larrea*. On the basis of our field investigations this species is entirely dependent as an oligolege on the pollen of *Larrea* and is also dependent upon that plant for virtually its entire nectar supply. Although the numbers of individuals present at the flowers varies widely from locality to locality (cf. Tables 2, 5, 7, and 9), it is, on the basis of our sampling program, one of the commonest pollen-collecting species associated with *Larrea*. In spite of its abundance and general occurrence throughout much of the range of that plant during the spring bloom, there is no evidence that any parasitic bee has established a host relationship with this seemingly ideal host.

1. *Heteranthidium larreae* (Cockerell)

FIGURE 14

Heteranthidium larreae was described originally from the Mesilla Valley, New Mexico (Cockerell, 1897b). Its range as known at present includes western Texas, southern New Mexico, central and southern Arizona, southern Nevada, Utah, and southern California, where it occurs widely over the Colorado and Mojave deserts from San Diego and Imperial counties to Inyo County. The species is a common spring *Larrea* oligolege, flying from late March to early May in the lower and more southerly deserts, in May and June to the north. We have found it at every one of our spring *Larrea*-collecting sites, often in large numbers. The males establish "loose" territories and usually patrol the plants at a height of 12–20 inches above the ground, well below the canopy of the plant, but periodically

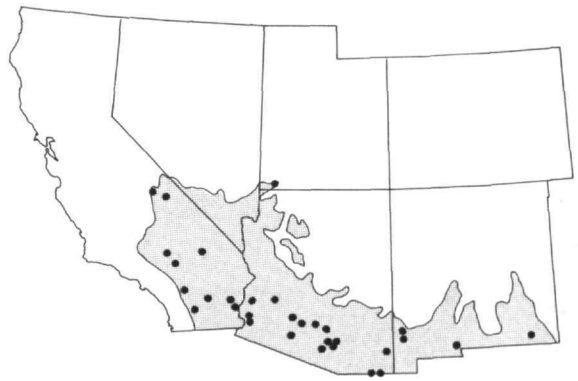

FIGURE 14.—*Heteranthidium larreae* (Cockerell).

cruising rapidly back and forth over the canopy. Males pounce upon and pursue females into the flowers and also pounce upon or pursue one another. We also observed them attacking female *Colletes* and honeybees, approaching from the rear in a mating position.

Grigarick and Stange (1968) provide detailed collection records for southern California, and MacSwain (1946) has described the nesting habits near Loving, New Mexico, where the species was nesting in a bare mound of hard-packed reddish-brown silt.

Genus *Anthidium*

This genus of robust bees contains a large number of species in the United States and adjacent Mexico. Our field investigations reveal the presence of four species at the flowers of *Larrea* (2 regular polyleges and 2 casual polyleges). One of the regular polyleges, *Anthidium sonorense*, may on the basis of further studies be shown to be an oligolege of *Larrea*. However, since one female was taken several years ago at the flowers of *Prosopis* in Death Valley (Grigarick and Stange, 1968:32) and since it is not known whether the female was collecting pollen, we have elected not to consider this species as an oligolege of *Larrea* even though all other records and our field studies indicate that it very well may be.

Three species of this genus (*A. cockerelli*, *A. jocosum*, and *A. sonorense*) are present at the flowers of *Larrea* only during the spring bloom, while a fourth species, *A. paroselae*, is found at the flowers

during both the spring and late-summer and fall blooms. It is a casual polylege, collecting pollen from a wide variety of plants.

2. *Anthidium (Anthidium) cockerelli* Schwarz

Anthidium cockerelli was first made known from a male captured at flowers of *Cercidium* near Oasis, California (Schwarz, 1928) and the female was subsequently reported from *Encelia* (Cockerell, 1938). It is a desert species, ranging from western Texas, through New Mexico and Arizona to southern Nevada, southern California, and Baja California Norte. Judging from the records published by Grigarick and Stange (1968) and material collected by Timberlake and by us, the females are polylectic, but have been taken at *Larrea* flowers in a number of localities. The flight period ranges from late March to early May in the low deserts to May and early June in the high deserts. In our sampling program we obtained, during the spring bloom of *Larrea,* a total of 54 specimens (20 males and 34 females) at various localities between Lordsburg, New Mexico, and Palm Springs, California (Tables 2, 5, 7, 9, 11, and 13).

3. *Anthidium (Anthidium) jocosum* Cresson

This is a widespread and obviously polylectic species, having been reported from Montana and Colorado, as well as Sonora, Mexico, and California (Grigarick and Stange, 1968). Although there is no reason to believe that it is an important *Larrea* bee, the female has been taken at *Larrea* by Timberlake near Victorville on the Mojave Desert, as well as by us at several localities on both the Sonoran and Chihuahuan deserts. California flight records range mostly from April to June.

4. *Anthidium (Anthidium) paroselae* Cockerell

Anthidium paroselae is a desert species. It ranges from Texas to Sonora, Mexico, and southern California (Grigarick and Stange, 1968), and we have found it at many of our study sites from Las Cruces, New Mexico, to Palm Springs, California. The species is polylectic and in southern California; females have been taken at flowers of *Palafoxia* and *Prosopis,* as well as *Larrea* (near Palm Springs, Timberlake). Two flight periods are evident, a vernal flight in April and May, and an autumnal flight in October. Newberry (1900) has reported some information on the nesting habits of this species.

5. *Anthidium (Anthidium) sonorense* Cockerell

This species, which has never been taken in large numbers, occurs on both the Sonoran and Mojave deserts during the spring. We have found it to be regularly associated with *Larrea* from which it collects both pollen and nectar. Years ago one of us (Linsley) obtained a female at the flowers of *Prosopis* in Death Valley, California (Grigarick and Stange, 1968:32), but it is not known whether pollen was being collected or not. Even though in this study we treat it as a regular polylege of *Larrea,* it is possible that further investigations will demonstrate that *A. sonorense* is an oligolege of *Larrea.*

Genus *Anthidiellum*

Only three species of this widely distributed genus of small, but robust, bees occur in North America. Of these only one of the species, *A. ehrhorni,* which occurs where *Larrea* grows, has been found to visit its flowers. Even then our field investigations indicate that these visitations are often sporadic in occurrence, and we have never observed large numbers of individuals at the flowers. Even so, *A. ehrhorni* visits the flowers of *Larrea* for pollen and nectar with sufficient regularity to be considered a casual polylege of that plant.

6. *Anthidiellum ehrhorni* (Cockerell)

This species was described originally from the Mojave Desert, and it occurs in the southern California deserts from Baja California Norte and San Diego and Imperial counties to the Central Valley, Death Valley, and Owens Valley, California, as well as southern Nevada to the north and the Sonoran Desert of Arizona to the east. Schwarz (1928) recorded the species from *Prosopis, Lotus,* and *Stephanomeria,* and there are females in the Timberlake collection from a variety of plants characteristic of arid and semiarid regions (see Grigarick and Stange, 1968, for others). However, females have been captured on *Larrea* by us and by others, while they were collecting pollen, although this

does not appear to be a preferred host. California flight records are mostly March and April on the low deserts, May and June on the high deserts and in the northern part of the range. In Arizona, two flight periods are evident, reflecting the spring and summer rain periods (March-April; August-September).

Genus *Ashmeadiella*

Members of this large Nearctic genus of small-sized species are occasionally encountered at the flowers of *Larrea* usually during the spring and early summer months, although one species, *Ashmeadiella bigeloviae* (Cockerell), is also known to visit these flowers in the late summer and fall (Hurd and Michener, 1955). With the exception of *Ashmeadiella (Arogochila) breviceps* Michener, which has been observed to collect pollen from *Larrea* at several localities on the Mojave and Colorado deserts, all the other species of *Ashmeadiella*—*A. bigeloviae* (Cockerell), *A. cazieri* Michener, *A. femorata* (Michener), *A. prosopidis* (Cockerell), and *A. rhodognatha* (Cockerell)—which have been obtained thus far at the flowers of *Larrea,* are either males or females in quest of nectar.

7. *Ashmeadiella (Arogochila) breviceps* Michener

This is an exceptionally small species of the genus *Ashmeadiella,* which flies during the spring months of March, April, and May on the Sonoran and Mojave deserts, ranging from near Tucson, Arizona, and adjacent northern Mexico (Sonora and Baja California Norte) to southern Nevada and the desert areas of southern California (Hurd and Michener, 1955). Even though the females of this species have been frequently taken at the flowers of *Larrea* while usually collecting pollen, they have also been collected with pollen in their scopae at several other desert plants, including *Dipetalia linifolia, Hyptis emoryi, Prosopis chilensis glandulosa,* and *Stephanomeria.*

Genus *Hoplitis*

Although there are a number of species of this chiefly Holarctic genus present in North America, only one species belonging to the monotypic subgenus *Dasyosmia* has evolved a dependent relationship on the pollen and nectar of *Larrea.*

8. *Hoplitis (Dasyosmia) biscutellae* (Cockerell)

FIGURE 15

This species is a *Larrea* oligolege. It occurs in the southwestern deserts from New Mexico to southern California, ranging from sea level (Coachella Valley, California) to at least 6000 ft above sea level (Inyo Mountains, California) (Michener, 1947). Flight occurs from late March to early May at lower elevations, in May and June at higher elevations. Detailed collection data from a large number of California localities, including many *Larrea*

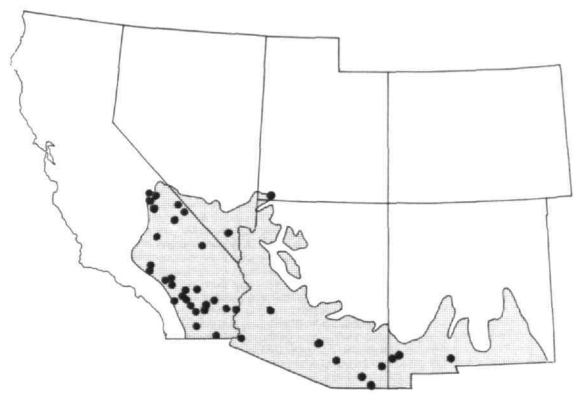

FIGURE 15.—*Hoplitis biscutellae* (Cockerell).

records, have been provided by Hurd and Michener (1955). On the basis of our field investigations, which have resulted in the collection of 180 specimens (129 females and 51 males), it is expected to occur wherever *Larrea* blooms in the spring, but only occasionally in large numbers (Tables 2, 5, 7, 9, 11–15).

Genus *Osmia*

Although there are many species of this Holarctic genus in North America, only three of these representing two subgenera have been found at the flowers of *Larrea.* All three of these species are present only during its spring bloom, and all are casual polyleges on that plant.

9. *Osmia (Chenosmia) clarescens* Cockerell

This is a southwestern desert, spring species oc-

curring from southern California to New Mexico. It is polylectic, taking pollen from a wide variety of plants. Timberlake captured a female at *Larrea* in Palm Canyon, Borrego State Park, San Diego County, California in mid-April. We have no further *Larrea* records.

10. *Osmia (Nothosmia) marginata* Michener

This is also a polylectic spring desert species, but more restricted than *O. clarescens,* being apparently confined to the Colorado Desert of southern California. Females have been taken at *Larrea* by Timberlake at Palm Springs, Riverside County, and Palm Canyon, Borrego State Park, San Diego County, California.

11. *Osmia (Nothosmia) titusi* Cockerell

Osmia titusi is an uncommon species of the southern deserts. It has been reported from New Mexico by Cockerell (see Sandhouse, 1939). Timberlake has taken it at *Larrea* at Edom (Thousand Palms), Riverside County, in March.

Genus *Megachile*

This genus, which occurs throughout much of the world, is represented in North America by many species belonging to several subgenera. In our sampling program six species of four subgenera (*Litomegachile, Xeromegachile, Pseudocentron,* and *Sayapis*) have been found with sufficient regularity at the flowers of *Larrea* to be included in this study. Other infrequent visitors of this genus found by us and others at flowers of *Larrea* include *Megachile howardi, M. newberryae, M. pseudolegalis,* and *M. xerophila.*

Of the species discussed below, three are regular polyleges of *Larrea,* and three are casual polyleges. All except one of these (*M. fucata*), which occurs during the spring bloom of *Larrea,* are present at the flowers during both the spring and the late-summer and fall blooms. Usually the presence of these species at or about the flowers is easily detected, owing to their noisy flight behavior. We have not found any species of *Megachile* which visit the flowers of *Larrea* only during the period of second bloom.

12. *Megachile (Litomegachile) gentilis* Cresson

This is a polylectic species ranging from the Pacific Northwest (Idaho, Oregon) to the desert Southwest (southern California, Arizona, New Mexico, Texas) and is adventive in Hawaii. It has been taken in flight from early April to early October (southern California). Butler (1965) records it from *Larrea* in Arizona, along with many other desert host plants, but does not give the locality or whether or not the bees were taking pollen. Our own *Larrea* samples have, for example, yielded occasional males and sometimes many pollen-collecting, as well as nectar-seeking, females (Tables 5, 7, 9).

Megachile gentilis nests in stems of elderberry (*Sambucus*), (Bechtel 1958) and other sites above ground. The females cut nest linings from a variety of leaves, including *Amaranthus, Boerhaavia,* and *Fraxinus* (Butler, 1965). Bechtel (1958) reared *Coelioxys novomexicana* Cockerell from several cell series. Krombein (1967) records this species as a frequent nester in trap-nests in Arizona.

13. *Megachile (Litomegachile) lippiae* Cockerell

Megachile lippiae is a widespread, polylectic species of northern and western North America, ranging from Quebec to Alberta and Oregon and south to Texas and west to southern California (Mitchell, 1935). It visits a wide variety of desert plants in Texas, New Mexico, Arizona, and southern California, and adults have been captured from early March to early September. Timberlake took a female at *Larrea* flowers, 7 miles northeast of Douglas, Arizona, on 11 August 1940. The specimen has only a few grains of pollen on the abdomen.

14. *Megachile (Litomegachile) texana* Cresson

This is a widely distributed North American species of leaf-cutting bees, ranging from the Atlantic region to the Pacific coast in the United States and southern Canada (Mitchell, 1935). From published records it is obviously polylectic, having been collected on many flowers, especially Leguminosae, Compositae, and Labiatae. Females are in flight from late spring to early fall. The species has been recorded from various desert plants by Butler (1965). In our experience it is the most abundant

and consistent of the *Megachile* taking pollen from *Larrea* in southeastern Arizona. We have found the females gathering *Larrea* pollen in large numbers (328 females and 27 males) at most of our sampling sites.

Megachile texana is a ground-nesting species (Krombein, 1953), and we have observed females entering and leaving nests under dead branches and other ground debris among plants in *Larrea* stands from which they were actively gathering pollen. However, we had no opportunity to observe whether or not they were using previously existing burrows or openings as suggested by Krombein (1970).

15. *Megachile (Xeromegachile) fucata* Cockerell

This species, described from Alamagordo, New Mexico, ranges through portions of Colorado, Utah, and Arizona to southern California (Mitchell, 1934, 1937a; Butler, 1965). In the Colorado Desert of southern California it has been taken at *Larrea* flowers in Palm Canyon, Borrego Valley, San Diego County, and at Twenty Nine Palms, San Bernardino County, by Timberlake, and in the vicinity of Oasis, Riverside County (Timberlake and Linsley). It is an early spring species, occurring mainly in March. Although females collect pollen from *Larrea,* they have also been captured at flowers of *Aster* and *Baileya* (Timberlake). Butler (1965) also records it as *M. histrata* Mitchell from *Cercidium* and *Prosopis.*

16. *Megachile (Pseudocentron) sidalceae* Cockerell

This is a common, widespread, polylectic desert species, ranging from Texas through New Mexico and Arizona to northern Mexico and southern California. Butler (1965) states that this is the most abundant species of *Megachile* in Arizona and records it from a wide variety of desert plants, including *Larrea,* but without further data as to locality, sex, or pollen collecting. Females bearing a few grains of pollen were taken by Timberlake from *Larrea* at Tombstone, Arizona, 13 August 1940, and we have found them actively collecting *Larrea* pollen in the San Simon Valley of Arizona and New Mexico and elsewhere. The flight period recorded by Butler (1965) ranges from 1 March to 2 October.

17. *Megachile (Sayapis) policaris* Say

Megachile policaris is a leaf-cutting bee of central and southern United States and Mexico, ranging from Florida to Nebraska and southern California. Females fly from April to October in the southwestern region. The species is polylectic with a wide range of hosts but with a perference for the pollen of helianthine Compositae. Butler records various desert plants as hosts in Arizona, including *Larrea.* We also have on occasion encountered the species at this host. Krombein (1967) has reared it in his trapnests set in Arizona and Florida.

Genus *Chalicodoma*

Of the many species of this genus which occur in the southwestern United States and adjacent northern Mexico where *Larrea* grows, our field investigations have established the more or less regular presence of only four species at the flowers of that plant (1 regular polylege and 3 casual polyleges). In addition, there are several other species like *Chalicodoma lobatifrons,* which on occasion are known to visit these flowers, usually for nectar. During the spring bloom of *Larrea* three of the species discussed below are present. Only one of these, *C. occidentalis,* also occurs during the second blooming period. *Chalicodoma spinotulata* occurs only during the late-summer and fall bloom.

18. *Chalicodoma (Chelostomoides) chilopsidis* (Cockerell)

This is primarily a vernal, resin-working desert species occurring from Texas and northern Mexico through New Mexico and Arizona to southern California, flying from April to June. Females visit a wide variety of desert plants, including *Acacia, Cercidium, Chilopsis linearis, Larrea, Olneya tesota,* and *Prosopis* (Mitchell, 1956; Butler, 1965). Timberlake captured a male at *Larrea* flowers 3.5 miles southeast of Agua Caliente, Maricopa County, Arizona 15 August 1935.

19. *Chalicodoma (Chelostomoides) discorhina* (Cockerell)

FIGURE 16

This is a typical vernal species of the Colorado

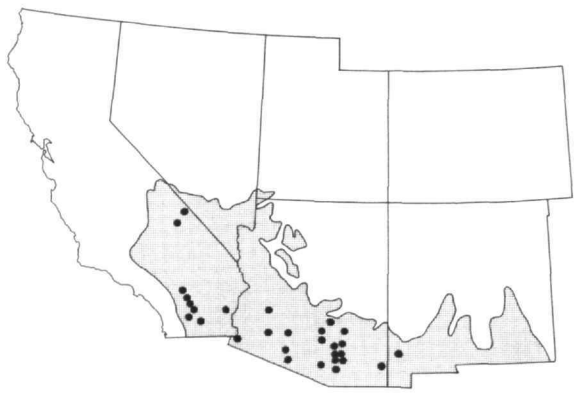

FIGURE 16.—*Chalicodoma discorhina* (Cockerell).

Desert of southern California, most of the early collections having been made in the vicinity of Palm Springs, Riverside County (Mitchell, 1937b). However, the present known range of the species extends into Baja California Notre and the Sonoran Desert of Arizona (Mitchell, 1956; Butler, 1965). Although females commonly take pollen from *Larrea,* they also visit *Cercidium* and, to a lesser extent, *Acacia* and *Prosopis*. The principal flight period in southern California is late March and April, in Arizona, April, May, and early June.

20. *Chalicodoma (Chelostomoides) occidentalis* (Fox)

This is a desert species, ranging from western Texas, New Mexico, and Arizona to northwestern Mexico (Sonora, Sinaloa), southern California, and Baja California (San Ignacio) (Mitchell, 1937b, 1956). Females have been taken at flowers of *Larrea, Cercidium, Chilopsis linearis, Nolina parryi, Tamarix gallica,* and *Schinus molle,* as well as while visiting annual plants, e.g., *Hoffmanseggia densiflora*. Flight records are mainly from June, July, and August. Krombein (1967) has reared this species from trapnests.

21. *Chalicodoma (Chelostomoides) spinotulata* (Mitchell)

This late summer and fall species ranges from Pecos, Texas, to southern California (Mitchell, 1956). Females have been taken from a wide variety of desert plants, mostly annuals. We have found them gathering pollen from *Larrea* in southeastern Arizona and western New Mexico. Other flower records are provided by Mitchell (1934, 1937c, 1956) and Butler (1965).

Genus *Coelioxys*

Several species of this genus, which is parasitic in the nests of *Chalicodoma* and *Megachile,* have been found visiting the flowers of *Larrea* for nectar, usually in the company of their hosts. Although we have not been able to identify many of the specimens obtained during the course of our field-sampling program, we and others have taken *Coelioxys hirsutissima* and *C. novomexicana* among others.

This is the only parasitic genus of Megachilidae which regularly is found at the flowers of *Larrea,* where it is most often observed sipping nectar from the outer or uppermost flowers on the plant. It is present during both the spring and late-summer and fall flowering periods of *Larrea.*

Family ANTHOPHORIDAE

Although 23 species of 10 genera (*Anthophora, Centris, Ceratina, Emphoropsis, Exomalopsis, Martinapis, Melissodes, Synhalonia, Xenoglossodes,* and *Xylocopa*) of this nearly cosmopolitan family have been found with sufficient regularity at the flowers of *Larrea* to be included in this study, not unexpectedly there are a number of additional species, both parasitic and pollen-collecting, which have been encountered on occasion at the flowers. Among these, for example, are additional species in such genera as *Anthophora* (*A. coptognatha, A. forbesi,* and *A. salazariae*) and *Synhalonia* (*S. cressoniana*), as well as one or more species belonging to the genera *Diadasia, Nomada, and Townsendiella.*

On the basis of our studies this family contains the largest number of species associated with *Larrea,* but the majority of these are casual polyleges and parasitic species. Only one species of this family, *Emphoropsis pallida,* has established an oligolectic relationship with *Larrea*. The other 22 pollen-collecting species are either regular polyleges (2 species) or casual polyleges (20 species). About half of these species (10) are present at the flowers only during the spring bloom of *Larrea,* while the

others (12) are present during both flowering periods (10 species) or only during the late-summer and fall blooms (2 species). Thus, even though there are a comparatively large number of both pollen-collecting and parasitic species of this family associated with *Larrea,* the level of dependence upon its pollen and nectar as a family is conspicuously less than that of the Colletidae and Andrenidae, which contain collectively 17 of the 22 known species of *Larrea* oligoleges.

There are a number of parasitic species of this family which are found at the flowers, often seeking nectar in the company of their pollen-collecting hosts. These include several species in each of the genera *Epeolus, Triepeolus,* and *Xeromelecta.* In addition, two other genera of these bees (*Ericrocis* and *Hexepeolus*) are each represented by a single species. As noted elsewhere, a few species of *Nomada* and *Townsendiella* are only occasionally encountered at the flowers.

Genus *Exomalopsis*

This is primarily a genus of Neotropical species, but there are a number of these species which either occur in the western United States or extend into that area from Mexico and Central America. Only one of these species occurs at the flowers of *Larrea* in sufficient numbers to be included in this study.

1. *Exomalopsis (Phanomalopsis) solani* Cockerell

This small, polylectic anthophorid was found visiting *Larrea* for pollen and/or nectar at several of our study sites. It was especially abundant near Portal, where most of the observed or captured females were taking pollen. They appeared to prefer to work plants of low stature. Described originally from Albuquerque, New Mexico, it is common in many parts of Arizona, New Mexico, and Texas. The nests are constructed in flat ground and are formed gregariously, with a single entrance for the colony, which may contain several hundred individuals.

According to Timberlake (1947) flowers visited, in addition to *Larrea,* include species of *Acacia, Baileya, Cassia, Chrysothamnus, Cleome, Croton, Eriogonum, Flaveria, Isocoma, Petalostemon, Solanum, Sphaeralcea,* and *Verbesina.*

Genus *Hexepeolus*

Only one of the two known species of this parasitic genus of bees has been found at the flowers of *Larrea.* This species, *Hexepeolus rhodogyne,* is a vernal species and is known only from the western portion of the Sonoran Desert in California, where it has never been observed in large numbers. At least on the basis of its known seasonal and geographic occurrence and, moreover, since it has been taken at the flowers of *Larrea* in company with the vernal *Ancylandrena larreae* on several occasions, it may be a parasite in the nests of that species. Confirmation of this suspected host relationship must, however, await further field investigations, especially the rearing of the parasite from the nests of its putative host.

Genus *Epeolus*

This genus of parasitic bees, which is primarily Holarctic in occurrence, is represented by a large number of species in North America. So far as known, the species are parasites in the nests of the genus *Colletes* and have frequently been found together at the flowers, visited by their pollen-collecting host species.

Although we have taken several species of this genus at the flowers of *Larrea,* only *Epeolus mesillae* has been obtained by us at these flowers with sufficient regularity to be included in this study. It is a vernal species, which we have found at most of our sampling sites in New Mexico, Arizona and southern California. Examples from the western Sonoran Desert tend to have the abdominal bands less distinctly defined than specimens to the east, and the dark areas are clouded with white pubescence. These western specimens are currently assigned to the subspecies, *Epeolus mesillae palmarum* Linsley.

Both sexes of *Epeolus mesillae* are common visitors to the flowers of *Larrea* in those areas where its presumed host, *Colletes clypeonitens,* occurs.

Genus *Triepeolus*

This genus of parasitic bees, which is chiefly centered in the Americas, contains a large number of species in North America, where many of its species are represented in or largely confined to the western United States. While we have obtained speci-

mens at many of our sampling sites, we have been unable to identify a number of these. Among those that we have recognized are *Triepeolus norae, T. townsendi,* and *T. verbesinae,* which sometimes are encountered at the flowers of *Larrea* in numbers. Most of our specimens of this genus have been collected during the late-summer and fall bloom.

In so far as known, most species of this genus are parasites in the nests of eucerine bees, especially those of the genera *Melissodes* and *Svastra,* but have also been reported to be parasites of several other anthophorid hosts.

Genus *Martinapis*

This genus currently contains only two species, each belonging to a different subgenus (Moure and Michener, 1955). One of these, *Martinapis (Svastropsis) bipunctata* (Friese), occurs in Argentina, and its intrafloral relationships are not known. The other species, *M. luteicornis,* belongs to the nominate subgenus and occurs in the southwestern United States and adjacent Mexico, where it is a regular polylege of *Larrea* during the spring on the Colorado Desert and the summer and fall on the Chihuahuan Desert.

2. *Martinapis (Martinapis) luteicornis* (Cockerell)

Females of this species visit *Larrea* for nectar and pollen both morning and evening, and males are also present at these times. Alternative pollen sources for this species are not well known. Both sexes appear to prefer legumes for nectar and have been taken by us in numbers on *Hoffmanseggia* and *Cercidium* before and after sunrise and on *Dalea* (MacSwain, 1957; Michener, 1966), and less frequently *Acacia,* in the morning and in the late afternoon. Only occasionally are females taken from these plants carrying pollen (MacSwain, 1957). In southeastern Arizona we have occasionally captured them while they were gathering pollen from *Solanum elaeagnifolium* in the morning (Linsley and Cazier, 1970) and once on *Mentzelia pumila* in the evening in the company of numerous nectar-drinking males (Linsley and Cazier, 1963). However, neither of these plants appears to be preferred as a pollen host.

All-day samples at Las Cruces, New Mexico, yielded 80 females taking pollen from *Larrea,* 34 taking nectar, and 28 nectar-seeking males. Females were most numerous between 0500 and 0630, but their activity period extended to about 0945 and resumed at 1730, extending to about 1845. They were also found at *Larrea* in all the San Simon Valley sites and at Soccoro and Elephant Butte in New Mexico and at Douglas, Arizona.

Genus *Melissodes*

This is a large genus of eucerine pollen-collecting bees, which, although present in both North and South America, is especially well represented by numerous species in North America. Of the many species and subgenera known to occur in the southwestern United States, our studies reveal that only two species, each belonging to a different subgenus, depend as polyleges upon the pollen and nectar of *Larrea.* Both of these species are present during the spring and the late-summer and fall flowering period of *Larrea.*

3. *Melissodes (Melissodes) paroselae* Cockerell

This is a polylectic species occurring from Baja California to extreme southern California, east across Arizona and New Mexico to extreme southwestern Texas and south through Sonora and Chihuahua to Tepic, Nayarit in Mexico (LaBerge, 1956). LaBerge records a long list of host flowers, including *Larrea.* We have found females collecting *Larrea* pollen in a number of our sampling sites in southeastern Arizona and New Mexico, but only at Antelope Pass in the Pelancillo Mountains, Hidalgo County, New Mexico, were they present in sufficient numbers to provide competition to *Melissodes tristis.*

4. *Melissodes (Eumelissodes) tristis* Cockerell

FIGURE 17

This is a widely distributed polylectic species occurring in southwestern United States and Mexico. LaBerge (1961) has recorded 881 females visiting 131 plant species representing 93 plant genera, without specifying which were taking pollen. Among these, he reported 104 females from *Larrea* (which he incorrectly assigned to the Leguminosae), based upon 11 collections, as against 336 from 134

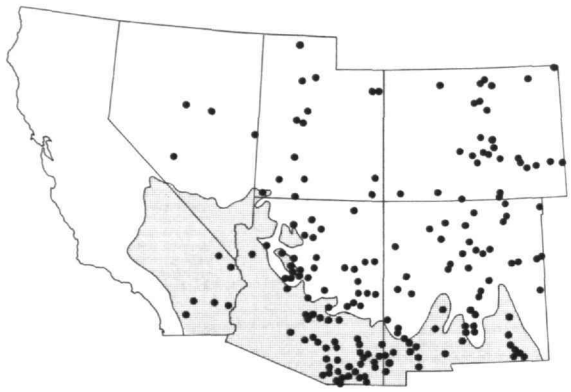

FIGURE 17.—*Melissodes tristis* Cockerell.

collections from Compositae, the preferred group of hosts for most species of *Eumelissodes*. He interprets collection data as indicating that the species has three generations a year in Texas, New Mexico, and Arizona, the first in the latter half of April and the first half of May, the second and largest in early to middle July, and the third in the first half of September. In southeastern Arizona there is usually some *Larrea* in bloom during these periods, at least in a year with the minimum necessary spring and summer rains.

This species was found in significant numbers at nearly all of our collecting sites in southeastern Arizona and New Mexico. The females collect large quantities of *Larrea* pollen and are regarded by us as polylectic regulars. In the San Simon Valley, females usually appeared at the flowers between 0600 and 0700, disappearing between 1600 and 1700. They were most active in the morning, with the peak of pollen collecting between 0800 and 0900. Males were present from 0900 until about 1300 but were rarely numerous. During the morning hours the females usually forage on the outer flowers in the upper half of the plant. As the day progresses, they are more commonly active inside the plant.

Males sleep gregariously on successive nights on the same or adjacent dry stems and flower heads, near but not touching one another, with head downward and antennae extended; nonnesting females sleep individually near the males and occasionally among them (Linsley, 1962a). In the San Simon Valley the most commonly observed sleeping substrate is dried stems of *Heterotheca subaxillaris*.

Genus *Xenoglossodes*

This genus, which contains about 15 species, occurs chiefly in the western United States and northern Mexico. Only the species discussed below has been encountered by us and others at the flowers of *Larrea*.

5. *Xenoglossodes eriocarpi* (Cockerell)

This is a desert species, ranging from Texas to southern California and is especially common in Arizona. It is primarily associated with desert Compositae, but Timberlake has taken the female at *Larrea* 22 miles north of Blythe. Most of our collections were made in August and September.

Genus *Synhalonia*

The bees of this North American genus fly during the spring months and are only exceptionally found in the summer. Timberlake (1969) remarks that under certain conditions a second generation may occur since specimens have been taken as late as August. He reports also that the females apparently never collect pollen from the flowers of Compositae, but visit the flowers of a wide range of plant families, including especially the Ranunculaceae, Leguminosae, Hydrophyllaceae, Boraginaceae, Ericaceae, and Saxifragaceae.

Our sampling program has established that four species of this genus depend upon *Larrea* as casual polyleges. In addition to these species, Dr. George E. Bohart and his colleagues have collected 12 males of *S. cressoniana* from the flowers of *Larrea* in Arizona (Salome, June 1973) and Utah (Santa Clara, 28 May 1973 and St. George, 26 March 1973).

6. *Synhalonia albescens* Timberlake

Synhalonia albescens is a species of the Mojave and Colorado deserts of California and the deserts of southern Nevada and central and western Arizona. Timberlake (1969) records females from *Larrea*, as well as from *Amsinckia, Salvia, Sphaeralcea, Oenothera* (*Chylismia*), and *Lycium*. It is a spring species with the principal flight in April,

and females which were collecting pollen at the flowers of *Larrea* were obtained by us at several localities.

7. *Synhalonia angustifrons* Timberlake

This species, which ranges from Oregon to northern Baja California and eastward to Arizona and Utah, has been recorded from the flowers of a wide variety of plants, including the Cruciferae, Leguminosae, Hydrophyllaceae, Rhamnaceae, and Zygophyllaceae (*Larrea,* during the spring bloom of that plant).

8. *Synhalonia primiveris* Timberlake

Timberlake (1969) reports that this is a common vernal species of our western deserts of California (Colorado and Mojave Deserts), Nevada, and Utah, and his records show that the species visits the flowers of a wide variety of desert shrubs and annuals. We have found it rather sparingly at several localities on the Colorado Desert of California (e.g., Palm Springs) as a casual polylege of *Larrea.*

9. *Synhalonia venusta venusta* (Timberlake)

This subspecies, which occurs in the Sonoran, Mojave, and Great Basin deserts of western North America, was originally described from a type-series of males and pollen-collecting females obtained at the flowers of *Oenothera clavaeformis* var. *auriantiaca* from the vicinity of Shoshone, Inyo County, California (Timberlake, 1961). Additional specimens were recorded by Timberlake from other localities, mainly at the flowers of other varieties of this plant (Onagraceae), but he also records two females from *Larrea.* In his systematic accounts of the genus *Synhalonia* (Timberlake, 1969), he lists additional females of this species, which were collected at *Oenothera clavaeformis* and *Sphaeralcea orcutti.*

Even though we have encountered this subspecies in numbers in Arizona at the flowers of *Larrea* on only one occasion (Table 9), none of the females were collecting pollen or had *Larrea* pollen in their scopae. While we have included this subspecies in this study, further field work is needed to establish its intrafloral relationship with *Larrea* since it appears likely that it may well be an oligolege of *Oenothera.*

The other subspecies, *S. venusta carinata,* appears on the basis of current knowledge to be a oligolege of *Clarkia* (Onagraceae).

Genus *Anthophora*

Four species representing two subgenera (*Anthophora* and *Micranthophora*) of this widely distributed genus have been established by our studies to be casual polyleges of *Larrea.* Three of these species are present at the flowers only during the spring bloom, while the fourth, *Anthophora urbana,* occurs during both the spring and the late-summer and fall flowering periods.

In the collections of the California Insect Survey, University of California, Berkeley, are 40 specimens (28 males and 12 females) of *Anthophora forbesi,* which were collected in the spring of 1951 at various localities within Death Valley, California, at the flowers of *Larrea.* Since there is no pollen in the scopae of these females, we conclude that both the females and the males were in the quest of nectar. As mentioned elsewhere, similarly we have excluded from this study several other species of this genus.

10. *Anthophora (Anthophora) linsleyi* Timberlake

Anthophora linsleyi is primarily a species of the Mojave Desert and adjacent areas in the southern San Joaquin and the Owens valleys of California. It is associated primarily with *Salvia carduacea* (Linsley and MacSwain, 1942), but females have been taken at *Lupinus odoratus* and *Phacelia distans* (Timberlake, 1941), as well as *Larrea.* The principal flight period is from late April to early June. Linsley and MacSwain (1942) have described the habits of the species. It nests gregariously, sometimes in very large numbers, either in banks or flat ground, usually in a hard-packed, dry, sandy conglomerate soil in an area where water is available throughout the nesting season.

11. *Anthophora (Anthophora) urbana urbana* Cresson

Anthophora urbana is one of the commonest and most widespread species of the genus in western

North America. It ranges from Washington and Idaho through Colorado, Utah, and California to Arizona, New Mexico, and northern Baja California and Sonora. It is highly polylectic, taking pollen during the spring, summer, and fall from a great variety of annuals and perennials. Both sexes visit *Larrea* for nectar, and females have been captured while gathering *Larrea* pollen at several localities in Arizona and southern California.

12. *Anthophora (Anthophora) californica albomarginata* Timberlake

This is a common, vernal, desert subspecies of California and Arizona, which is on the wing from early spring into early summer, but on occasion has been collected well into the middle of summer. It is a polylectic species obtaining its pollen from a wide variety of desert plants, including both annuals and perennials. During the course of our field investigations we have taken it in May at the flowers of *Larrea* (Table 7) collecting pollen. We have also taken its related subspecies *A. californica texana* in August (Table 6) seeking nectar.

13. *Anthophora (Micranthophora) hololeuca* Cockerell

This is a spring desert species ranging from southern California into Baja California, southern Arizona, and Sonora, Mexico. The species is polylectic, but the females are most commonly taken at legumes (e.g., *Dalea, Acacia, Cercidium*). Timberlake has taken both sexes visiting *Larrea* at Edom (Thousand Palms), Riverside County, California, in March and April. Our own sampling program reveals that it is a casual polylege of *Larrea*.

Genus *Emphoropsis*

In North America this genus occurs transcontinentally in the United States, but most of the species are found in the west. Only a single species, discussed below, has been found at the flowers of *Larrea*. It is the sole representative of the family Anthophoridae, which appears to be an oligolege of *Larrea*.

14. *Emphoropsis pallida* Timberlake

Emphoropsis pallida appears to be a *Larrea* oligolege, although in the absence of *Larrea* flowers or when they are scarce, females will take pollen from other plants (cf. Bohart, Torchio, Maeta, and Rust, 1972; Linsley, MacSwain, and Raven, 1963a). It is a spring species, flying primarily in March in the low deserts to May in the north. The range includes most of the Colorado Desert from Imperial County northward on both sides of the Colorado River to Needles, San Bernardino County, California, and Lake Havasu, Mohave County, Arizona, west to Borrego Valley, San Diego County, and Palm Springs, Riverside County, and northeast to Washington County, Utah (Timberlake, 1937; Bohart et al., 1972). The species nests in sandy slopes along water courses or permanent bodies of water (Bohart et al., 1972).

We have found females taking pollen from *Larrea* very early in the morning, as did Bohart et. al., who reported from their study site near the Colorado River:

> Flight activity began shortly before sunrise and continued until sunset. However, most flight occurred between 1 hour after sunrise and 2 hours before sunset. The first load of pollen was returned to the nest 1 hour after sunrise.
>
> Bees traveling from the nesting site to the host plants generally flew in a straight line from 3.0 to 3.5 m above ground. Returning bees usually circled the area above their nests once before landing in front of the entrances. Two such pollen-collecting trips were timed at 29 and 31 minutes, respectively.

Genus *Centris*

Five species of this primarily Neotropical genus regularly visit the flowers of *Larrea* in the southwestern United States and adjacent northern Mexico. While occasionally the females collect pollen from these flowers (Tables 5, 7), most seek nectar (Table 2, 8–11, 13) and in the process become heavily dusted with pollen on their undersurfaces and no doubt are effective in the transfer of pollen.

Two of the five *Larrea*-visiting species (*C. hoffmanseggiae* and *C. pallida*) have recently been assigned by Snelling (1974) to the subgenus *Xerocentris*, which is represented by five species in North America and by a single species in South America (Chile and Peru). The other three *Larrea*-visiting

species of the southwestern United States and northern Mexico are considered by Snelling (1974) to belong to the subgenus *Paracentris* and have been studied previously by Timberlake (1940) and Snelling (1956, 1966).

15. *Centris (Xerocentris) hoffmanseggiae* Cockerell

This is primarily a desert species, which flies during the spring and ranges from New Mexico into southern California, but has been recorded from Hastings Natural History Reservation in the Santa Lucia Mountains, Monterey County, California (Snelling, 1956). It has previously been reported from the flowers of *Larrea,* as well as those of *Cercidium, Lotus, Prosopis, Penstemon, Dicentra,* and alfalfa (Snelling, 1956, 1974).

In our field investigations we encountered it during April and May at the flowers of *Larrea,* usually seeking nector, but sometimes the females were also collecting pollen. Specific localities where we observed the species at *Larrea* flowers include Lordsburg, New Mexico, in May (Table 2) and the following localities in Arizona: 1 mile north of Portal in May (Table 5), Douglas in May (Table 7), Tucson Airport in May (Table 11), 18 miles west of Tucson in May (Table 9) and Yuma in April (Table 12).

16. *Centris (Xerocentris) pallida* Fox

This species, which flies during the spring and early summer, has been recorded from northern Mexico, Arizona, the Colorado Desert of California, and Santa Catalina Island off the coast of southern California (Snelling, 1956, 1974). It visits the flowers of a number of desert shrubs including *Cercidium, Dalea, Larrea,* and *Olneya.* In our sampling program in Arizona we encountered it in May at Douglas (Table 7) and near Tucson (Table 9). Like the other species of *Centris* found at the flowers of *Larrea,* both sexes chiefly seek nectar, but on occasion the females do collect pollen.

17. *Centris (Paracentris) atripes* Mocsáry

This species, which flies from May into September, occurs in Costa Rica and over much of Mexico (Oaxaca, Puebla, Guerrero, Nuevo Leon, Tamaulipas, Durango, Chihuahua, and Baja California) into Texas, New Mexico, Arizona, and California (Snelling, 1966, 1974). It is a casual polylege of *Larrea* and is present at the flowers during both the spring and late-summer and fall flowering periods of that plant (Tables 5, 7, and 8).

18. *Centris (Paracentris) cockerelli resoluta* Cockerell

According to Snelling (1966, 1974) this subspecies, which most often has been referred to as *C. lanosa,* inhabits Arizona, Nevada, California, Sonora, and Baja California. The nominate subspecies occurs in Texas, New Mexico, Tamaulipas, Nuevo Leon, and Chihuahua and intermediate specimens of these two subspecies are found in western New Mexico, Chihuahua, and eastern Arizona and Sonora (Snelling, 1966, 1974).

Centris cockerelli resoluta is a common desert species, which flies in the spring and early summer, visiting the flowers of a number of shrubs and trees, including *Cercidium, Dalea, Krameria,* and *Prosopis* (Snelling, 1956), from late March to early June. During our sampling program of *Larrea* flowers we encountered it at four localities in Arizona: 1 mile north of Portal in May (Table 5), 18 miles west of Tucson in May (Table 9), Tucson International Airport in May (Table 11), Yuma in April (Table 12), and at Palm Springs, California, in April (Table 13). It is significant that of the 72 females obtained at the flowers of *Larrea* 1 mile north of Portal, Arizona (Table 5), only 3 were collecting pollen. The other 69 females were seeking nectar. Thus this subspecies is very much like the other species of *Centris,* found by us, that visited flowers of *Larrea* chiefly for nectar. However, Dr. G. E. Bohart obtained a large series (77 females and 102 males) of this subspecies at St. George, Utah, in late May and found that most of the females were collecting pollen (Table 15).

At Palm Springs, California, in early April of 1974, we observed that the males of this subspecies were flying in established territories in front of certain *Larrea* plants. They flew zigzag courses facing the plant, some 4 to 5 feet away from the plant and about 12 to 15 inches above the ground. They darted at other insects entering the territory, and when another male appeared, they would attack the intruder and frequently the combatants would tumble to the ground only to separate in a few sec-

onds. The intruding male invariably flew off while the original male would resume its territorial flight.

19. *Centris (Paracentris) rhodopus* Cockerell

This is a chiefly desert species ranging from Texas to southern California and northern Mexico. It is common during the spring, summer, and fall, visiting a wide variety of plants for nectar and pollen, including *Larrea,* which, however, is not a preferred host. It has been reported actively collecting pollen from *Solanum elaeagnifolium* and *S. rostratum* in the morning near Douglas, Arizona (Linsley and Cazier, 1963), and we have taken it in small numbers at *Hoffmanseggia, Acacia,* and *Dalea.* During our sampling program we found it frequently at the flowers of *Larrea* in western New Mexico, southern Arizona (Tables 9, 10–11), and Sonora, Mexico.

Genus *Xeromelecta*

Three of the four species included in this genus of parasitic bees are present in North America (Hurd, 1953) and each has been taken by us at flowers of *Larrea.* Two of these species, *Xeromelecta californica* and *X. interrupta,* belong to the subgenus *Melectomorpha* and occur at the flowers of *Larrea* during both the spring and late-summer blooms. The other species, *X. larreae,* is the sole representative of the nominate subgenus and is on the wing only during the spring bloom in April and May. The latter species was described from a female collected at the flowers of *Larrea* in Mesilla Park, New Mexico, by Cockerell (1900) and ranges into the Colorado and Mojave deserts (Hurd and Linsley, 1951). Although both sexes visit *Larrea* flowers, the females being parasitic do not collect pollen, and neither sex is equipped with plumose hairs likely to transport pollen accidentally.

Genus *Ericrocis*

This genus of parasitic bees, which contains three species, occurs over much of the arid areas of western North America. It is represented at the flowers of *Larrea* by a single species, *Ericrocis arizonensis,* which is present during both the spring and late-summer blooms, often in the company of its pollen-collecting hosts (*Centris* spp.).

Genus *Ceratina*

Although there are 22 species of this genus of small carpenter bees known to occur in America north of Mexico (Daly, 1973), only two species, both members of the subgenus *Zadontomerus,* have been taken at the flowers of *Larrea.* One of these species, *Ceratina apacheorum,* is discussed in the species account which follows, and the other species, *C. arizonensis* Cockerell, is not included in this study since it has been collected at *Larrea* flowers on only one occasion (Sabino Canyon, Pima County, Arizona, 21 March, 1961, J. C. Bequaert), and all of the specimens (8) are males. Even though one or more of these specimens was reported by Daly (1973:42) to be a female, he has reexamined the series and has verified that all of the specimens are males.

20. *Ceratina (Zadontomerus) apacheorum* Daly

This species, a member of the Nanula species group (Daly, 1973), inhabits not only the more arid areas of the southwestern United States (New Mexico, Arizona, Nevada, and southern California), but also ranges northward to Ormsby and Washoe counties in Nevada and northwestwardly into the Mt. Pinos region of the southern central coast mountains of California. It flies from early spring (16 February) well into the fall (27 October) and has been taken at the flowers of a wide variety of annuals and perennials including *Larrea* (Daly, 1974:38–39). In our sampling program, we obtained pollen-collecting females at the flowers of *Larrea* on 19 May, 1973 between 0900 and 0929 at 18 miles west of Tucson, Arizona (Table 9).

Genus *Xylocopa*

Of the three species of large carpenter bees which have been encountered at the flowers of *Larrea,* the commonest and most regular visitor is *Xylocopa californica arizonensis* Cresson. Like the other two species of *Xylocopa* (*X. tabaniformis androleuca* and *X. varipuncta*) often found at these flowers, this species ranges over much of the southwestern United States and adjacent Mexico well beyond the range of *Larrea.* All three species visit many different kinds of plants for nectar, pollen, or both, and perhaps because of their comparatively large

size, relatively somber coloration, and rather lumbering flight, the carpenter bees are among the more conspicuous visitors at the flowers of *Larrea*. In marginal situations at or adjacent to the peripheral limits of *Larrea*, sometimes other large carpenter bees (e.g., *X. californica diamesa*, *X. tabaniformis orpifex*, and *X. mexicanorum*) are occasionally found at the flowers of *Larrea*.

21. *Xylocopa (Xylocopoides) californica arizonensis* Cresson

FIGURE 18

Xylocopa c. arizonensis is a large, dark blue bee with the wings heavily infuscated with black. The female is polylectic, visiting a wide variety of plants throughout its range, which includes parts of California, Arizona, Nevada, New Mexico, Utah, Texas, and Mexico (Hurd, 1955). However, this bee is most abundant in the southwestern deserts, where its preferred nesting substrates include *Agave*, *Yucca*, and *Dasylirion* (Hurd, 1954, 1955, 1958, 1961 and Hurd and Moure, 1963).

Females of this carpenter bee take pollen and nectar from *Larrea*, primarily in the early morning (0600–0900). However, their activity at the flowers generally decreases during midday (Table 5). During the spring the females make extensive use of *Larrea* pollen, but our observations during the second bloom of *Larrea* reveal that floral visits are made chiefly for nectar. Males take nectar throughout the day.

Early in August large numbers of freshly emerged individuals may be seen flying about *Larrea* and taking nectar. In one visual count, males outnumbered females about 7:1. When a female flew into the *Larrea* site, one or more males immediately pursued her. Single males followed about 6 inches behind the female, two or more males circled her as she flew. When the female alights on a flower, the pursuing male pounces on her, often knocking her to the ground. Females so disturbed usually flew off high in the air at a slight angle to the vertical, with one of the males in pursuit. As the season progresses, pollen-collecting females are usually not disturbed by males. Both sexes forage on the upper and outer parts of the *Larrea* plant.

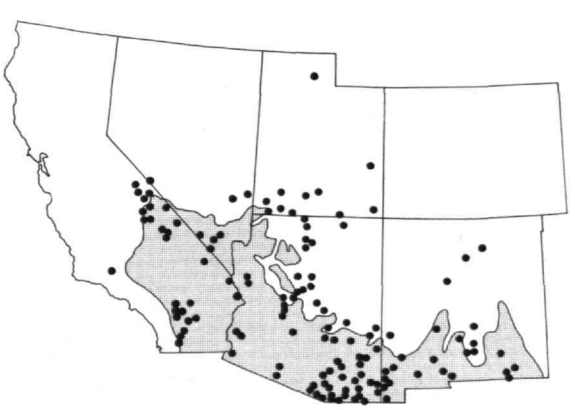

FIGURE 18.—*Xylocopa californica arizonensis* Cresson.

Alternate pollen sources for *Xylocopa* were numerous, including *Prosopis* and *Acacia*, but were not specifically investigated in terms of competition with *Larrea*.

22. *Xylocopa (Notoxylocopa) tabaniformis androleuca* Michener

This carpenter bee, which occurs in the mountains of the more arid environments of the western United States and adjacent Mexico (Nevada, Utah, Arizona, New Mexico, and transmontane California), has been found on occasion in numbers at the flowers of *Larrea* and other desert shrubs and trees. While something is known of its nesting and floral-visiting habits (Hurd, 1958; O'Brien and Hurd, 1965), its greatest period of observed diurnal activity appears to be concentrated during the evening hours shortly before and after sunset. At least at one locality (Surprise Canyon, Panamint Mountains, California), however, a few males and females were noted during the sunny early morning hours (0600–0900, PDT) in the quest of nectar at the flowers of *Larrea* (females) and *Stanleya pinnata* (males). No additional activity was noted until mid-afternoon when a few males were again observed at the flowers of *Stanleya*.

23. *Xylocopa (Neoxylocopa) varipuncta* Patton

The darkly colored females of this strongly dichromatic species are frequently encountered in large numbers flying about the flowers of various introduced and native plants, including *Larrea*, from early in the morning until late in the afternoon. Although the tawny colored males are less

often observed at the flowers, we have seen them on a number of occasions in New Mexico, Arizona, California, and Baja California sipping nectar at the flowers of *Larrea* in both the morning and afternoon hours. Even though the males have been observed in hovering flights about and within the branches and foliage of a selected tree or group of bushes for hours at a time (Hurd, 1958), we have not observed this behavior around the bushes of *Larrea*. Throughout its range, which encompasses and extends well beyond that of *Larrea* in North America, *X. varipuncta* is active during the spring, summer, and fall months of the year.

Family APIDAE

Species of this family are found throughout much of the world from the high Arctic latitudes to or near the southern limits of the major land masses of the Southern Hemisphere. In America north of Mexico the family is represented most conspicuously by the familiar introduced European honeybee, *Apis mellifera,* and many native species of bumblebees (*Bombus* and *Psithyrus*). The only other member of this family known to occur in the United States is a species of the Neotropical genus *Eulaema,* which was found years ago in the Brownsville area of Texas.

Only two species of this family are known to visit the flowers of *Larrea* in North America.

Genus *Bombus*

Although there are a number of species of this genus present in North America, only one species, *Bombus pennsylvanicus sonorus,* occurs widely throughout the more arid areas of the southwestern United States and adjacent Mexico. Since it is known to obtain nectar, pollen, or both from a wide variety of plants, it is not surprising that it visits the flowers of *Larrea,* sometimes in large numbers, especially when other floral sources are scarce or absent.

1. *Bombus (Fervidobombus) pennsylvanicus sonorus* Say

This bumblebee, like its congeners, is polylectic, gathering pollen from a wide variety of flowering plants. Milliron (1973) enumerates 18 genera among the plant hosts represented among 792 specimens of both sexes examined by him and adds eight more reported by Lutz and Cockerell (1920). *Larrea* is not included among these, although Timberlake has taken specimens from that host at Tombstone, Arizona, and we have found it at the flowers of *Larrea* at many of our study sites. In the San Simon Valley of Arizona and New Mexico it is active throughout the day, working the flowers of early blooming plants such as *Solanum* before sunrise (Linsley, 1962b) and late afternoon or early evening flowers, such as *Mentzelia* (Linsley and Hurd, 1959).

Stephen (1957) regards this bumblebee as limited to California, but Milliron (1973) gives the range as California to Texas, and Mexico (including Lower California) to Yucatan.

Genus *Apis*

This genus, which is native to Eurasia and Africa (Michener, 1974), is well established in the Western Hemisphere, having originally been introduced from Europe into both North and South America. Only one species is represented, but there is much variation evident in the introduced species owing to hybridization of the several introduced races or strains.

2. *Apis (Apis) mellifera* Linnaeus

The introduced honeybee, *Apis mellifera,* the most polylectic of all bees, assiduously works *Larrea* flowers for pollen and nectar in those areas where the workers have access to the plants growing along permanent desert water courses, lakes, or various impoundments where year-around access to moisture and forage is available to sustain feral colonies or where commercial apiaries are temporarily or permanently maintained in the vicinity. Thus, over vast areas of the *Larrea* belt where these conditions do not exist, the flowers are inaccessible to honeybees, and all-day surveys will fail to encounter a single individual.

Appendix: Tables

TABLE 1.—*Las Cruces, New Mexico, August: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no sample; centigrade temperatures in parentheses; sunrise: 0528; sunset: 1853; sky clear or with broken clouds; collections by E. G. and J. M. Linsley)

Species		0500 0529 (17)	0530 0559 (17)	0600 0629 (18)	0630 0659 (20)	0700 0729 (23)	0730 0759 (25.5)	0800 0829 (28)	0830 0859 (29)	0900 0929 (30)	0930 0959 (31)	1000 1029 (32)	1030 1059 (32)	1100 1129 (32)	1130 1159 (33)	1200 1229 (33)	1230 1259 (33)	1300 1329 (33)	1330 1359 (34)	1400 1429 (34)	1430 1559 (34)	1600 1629 (34.5)	1630 1659 (34.5)	1700 1729 (34)	1730 1759 (34)	1800 1829 (31)	1830 1845 (31)	*Totals*
Caupolicana yarrowi	♀P	9	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13
	♀N	5	2	3	–	–	–	–	–	–	–	–	–	–	–	–	*	–	–	–	*	–	–	–	1	4	1	16
	♂N	2	5	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	2	2	18
Martinapis luteicornis	♀P	14	18	13	9	8	5	7	4	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	88
	♀N	4	5	2	3	2	2	1	2	1	–	–	–	–	–	–	*	–	–	–	*	–	–	–	–	7	4	33
	♂N	–	–	1	4	7	6	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	30
Agapostemon melliventris	♀P	1	2	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	1	1	3	17
	♀N	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	*	–	–	–	*	–	–	–	–	–	–	1
	♂N	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Megachile texana	♀P	–	–	1	1	2	3	6	4	3	6	4	5	7	3	3	–	6	4	3	–	4	3	1	2	–	–	71
	♀N	–	–	–	2	2	1	1	2	1	1	1	2	3	–	–	*	–	1	2	*	2	3	2	1	–	–	27
	♂N	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Melissodes tristis	♀P	–	–	–	1	4	4	5	5	4	3	4	4	7	4	2	–	7	4	4	–	2	2	1	5	–	–	72
	♀N	–	–	–	–	2	1	2	1	–	–	–	1	3	–	–	*	–	1	2	*	3	2	4	1	1	–	24
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Miscellaneous species [1]	♀P	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	–	–	–	*	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	1	–	–	4
Totals		35	36	28	21	30	22	29	18	14	14	9	13	21	7	6	–	13	12	11	–	11	11	11	14	16	17	419

[1] Miscellaneous species include *Ashmeadiella bigeloviae*, ♀P; *Triepeolus norae*, ♀; *Triepeolus townsendi*, ♀; and *Triepeolus* sp., ♀. Honeybees were present throughout the sampling period.

TABLE 2.—*Lordsburg, New Mexico, May: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no count; centigrade temperatures in parentheses; collections by P. D. Hurd, Jr., E. G. and J. M. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529	0530 0559 (18)	0600 0629 (18)	0630 0659 (19.5)	0700 0729 (22)	0730 0759 (22)	0800 0829 (27.5)	0830 0859 (24)	0900 0929 (25)	0930 0959	1000 1029	1030 1059	1100 1129	1130 1159	1200 1229	1230 1259	1300 1329	1330 1359	1400 1429	1430 1459	1500 1529	1530 1559	1600 1629	1630 1659	*Totals*
Ancylandrena larreae	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Colletes louisae	♀P	–	–	–	1	1	3	2	3	1	–	–	–	–	–	–	–	–	–	1	2	1	1	–	–	16
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	3	–	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	8
Anthophora urbana	♀P	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	♀N	–	1	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	1	1	•	•	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Colletes wootoni	♀P	–	–	–	1	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	7
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centris hoffmanseggiae	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	♀N	–	–	–	1	2	1	1	1	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	6
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heteranthidium larreae	♀P	–	–	–	–	–	1	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	3	1	–	–	–	–	–	•	•	4
	♂N	–	–	–	1	3	6	3	3	4	–	–	–	–	–	–	2	2	3	2	3	1	1	–	–	34
Xylocopa californica arizonensis	♀P	–	–	–	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	5
	♀N	–	–	–	1	1	–	–	1	–	•	•	•	•	•	•	–	–	–	–	–	–	1	–	–	4
	♂N	–	–	–	–	–	4	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	8
Megachile texana	♀P	–	–	–	–	1	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	–	–	–
	♂N	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Lasioglossum sisymbrii	♀P	–	–	–	–	1	2	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centris pallida	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	2	–	•	•	2
	♂N	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	5

Melissodes	♀P	–	–	–	–	–	1	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
tristis	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Colletes	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
salicicola	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	1	–	–	•	•	1
	♂N	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	4
Hesperapis	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	2	–	–	–	6
larreae	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3
Anthophora	♀P	–	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	5
californica	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	1	–	•	•	1
	♂N	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Xylocopa	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
varipuncta	♀N	–	–	–	–	–	–	1	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hoplitis	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1	1	–	4
biscutellae	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	2
Miscellaneous	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
species[1]	♀N	–	–	–	–	–	–	–	–	–	•	•	•	•	•	•	–	–	–	–	–	–	–	•	•	–
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals		–	5	–	6	11	27	24	21	10	–	–	–	–	–	–	5	3	4	11	14	12	9	–	–	162

[1] Miscellaneous species in small numbers included pollen-collecting females of *Agapostemon angelicus, A. melliventris, Anthidium cockerelli, Ashmeadiella bigeloviae, Colletes covilleae,* and *Megachile gentilis.* Nectar-drinking females included *Megachile sidalceae* and *Xeromelecta interrupta* and males of *Colletes clypeonitens. Perdita* were present but not numerous.

TABLE 3.—*Granite Pass, New Mexico, August: Half-hour counts on principal species* (P=pollen; N=nectar only; *=no samples; centigrade temperatures in parentheses; collections by M. A. Cazier, E. G. and J. M. Linsley, and T. Zavortink)

Species		0500 0529	0530 0559	0600 0629	0630 0659	0700 0729	0730 0759	0800 0829	0830 0859 (29)	0900 0929 (30)	0930 0959 (31.5)	1000 1029 (32)	1030 1059 (34)	1100 1129 (34)	1130 1159	1200 1229	1230 1259	1300 1329	1330 1359	*Totals*
Caupolicana yarrowi	♀P	–	–	–	2	1	3	1	–	–	–	–	–	–	–	–	–	–	–	7
	♀N	–	–	–	–	6	3	1	1	–	–	–	–	–	–	–	–	–	*	11
	♂N	–	–	3	3	26	14	13	4	3	–	–	–	–	–	–	–	–	–	66
Martinapis luteicornis	♀P	–	–	1	3	4	2	1	–	–	–	–	–	–	–	–	–	–	–	11
	♀N	–	–	–	2	1	1	1	–	1	–	–	–	–	–	–	–	–	*	6
	♂N	–	–	–	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	11
Protoxaea gloriosa	♀P	–	–	–	–	–	2	2	3	–	1	–	–	–	–	–	–	–	–	8
	♀N	–	–	–	–	–	–	–	3	2	1	5	–	–	–	–	1	2	*	14
	♂N	–	–	–	–	3	2	2	3	5	4	3	2	–	–	–	–	–	–	24
Megachile texana	♀P	–	–	–	–	2	1	1	3	2	3	2	1	4	2	1	2	1	–	25
	♀N	–	–	–	–	1	1	1	1	–	–	–	1	–	–	–	1	–	*	6
	♂N	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	2
Melissodes tristis	♀P	–	–	–	–	–	–	–	2	1	1	2	3	5	4	2	1	1	–	22
	♀N	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	2	–	*	5
	♂N	–	–	–	–	2	1	2	–	–	1	3	–	–	–	–	–	–	–	9
Nomia mesillensis	♀P	–	–	–	–	2	1	2	2	3	5	6	2	4	6	2	1	1	–	37
	♀N	–	–	–	–	–	–	–	1	–	5	4	4	–	2	–	2	–	*	18
	♂N	–	–	–	–	–	–	–	3	1	–	–	–	–	–	–	–	–	–	4
Xylocopa c. arizonensis	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	2	1	2	3	–	–	1	1	–	1	–	1	–	*	12
	♂N	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Colletes wootoni	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	0
	♂N	–	–	–	–	–	–	2	4	–	1	1	–	–	–	–	–	–	–	8
Triepeolus spp.	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	1	1	–	–	–	1	–	–	–	–	–	–	–	*	3
	♂N	–	–	–	–	1	–	–	–	–	–	1	1	–	–	–	–	–	–	3
Miscellaneous species[1]	♀P	–	–	–	–	–	–	1	–	–	1	–	1	–	2	–	–	–	–	5
	♀N	–	–	–	–	–	–	–	–	2	1	–	–	–	1	–	–	–	*	4
	♂N	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	2
Totals		0	0	4	13	55	36	34	34	21	25	30	18	14	18	6	11	5	0	324

[1] Miscellaneous species were few but included *Megachile sidalceae*, ♀ ♀N and P; *Megachile* sp., ♂ ♀N; *Chalicodoma spinotulata*, ♀ ♀P; *Triepeolus* spp, ♂ ♀; and *Dialictus* spp. Occasional honeybees were seen taking nectar or pollen.

TABLE 4.—*Antelope Pass, New Mexico, August: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no count; centigrade temperatures in parentheses; sunrise: 0534; sky clear but clouds appearing about 1300 and thunder showers about 1400; collectors E. G. and J. M. Linsley)

Species		0500 0529 (18)	0530 0559 (20)	0600 0629 (20)	0630 0659 (21)	0700 0729 (24)	0730 0759 (25)	0800 0829 (26.5)	0830 0859 (31.5)	0900 0929 (33)	0930 0959 (34.5)	1000 1029 (36)	1030 1059 (37)	1100 1129 (37)	1130 1159 (37)	1200 1229 (37.5)	1230 1259 (37.5)	1300 1329 (37)	1330 1359 (37.5)	1400 1429	*Totals*
Caupolicana	♀P	4	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
yarrowi	♀N	–	–	2	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	*	6
	♂N	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Protoxaea	♀P	–	–	–	–	4	10	10	16	13	19	7	1	1	–	–	–	–	–	–	81
gloriosa	♀N	–	–	–	2	3	–	–	7	4	–	–	3	4	3	4	6	5	1	*	42
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Melissodes	♀P	–	–	–	–	6	12	8	6	7	12	7	9	5	3	6	3	2	2	–	88
tristis	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2	2	*	6
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Melissodes	♀P	–	–	–	–	–	1	2	1	2	5	3	2	3	–	4	–	1	1	–	25
paroselae	♀N	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	*	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Megachile	♀P	–	–	–	–	–	1	–	–	1	2	2	1	–	1	–	1	2	–	–	11
texana	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	*	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Nomia	♀P	–	–	–	–	–	–	–	–	–	1	4	4	10	13	17	12	11	6	–	79
mesillensis	♀N	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	1	1	2	*	6
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Miscellaneous[1]	♀P	–	–	–	–	1	1	2	1	1	1	–	–	1	–	–	–	–	–	–	8
Polylectic	♀N	–	–	–	–	–	1	–	–	–	1	–	–	–	1	–	–	2	–	*	5
Regulars and Casuals	♂N	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Totals		4	5	4	5	15	26	22	32	28	41	24	21	25	24	32	24	26	15	0	373

[1] Miscellaneous species present in small numbers included pollen-collecting females of *Anthophora montana* (0700–1100), *Melissodes paroselae* (0800), *Martinapis luteicornis* (0800), *Agapostemon tyleri* (0830), *Xylocopa californica arizonensis* (0915), and nectar-drinking males and females of *Triepeoplus* sp. and females of *Centris rhodopus* (0730–1300). *Perdita larreae* and *P. semicaerulea* were present from 0930 to 1400, when sampling was terminated because of inclement weather, but they were irregularly distributed and were not collected with sufficient consistency to tabulate.

TABLE 5.—*Portal, Arizona, 1 mile N, May: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no samples; centigrade temperatures in parentheses; sunrise: 0525; sky clear; collections by P. D. Hurd, Jr., E. G. and J. M. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529	0530 0559 (15)	0600 0629 (17)	0630 0659 (21)	0700 0729 (21)	0730 0759 (23.5)	0800 0829 (24)	0830 0859 (23)	0900 0929 (25)	0930 0959 (26)	1000 1029 (27)	1030 1059 (27)	1100 1129 (29)	1130 1159 (30)	1200 1229 (30.5)	1230 1259 (30.5)	1300 1329 (30)	1330 1359 (30.5)	1400 1429 (30)	1430 1459 (29)	1500 1529 (29)	1530 1559 (29)	1600 1629 (28.5)	1630 1659 (28)	1700 1729 (27)	1730 1759 (25)	*Totals*
Heteranthidium	♀P	–	–	2	7	8	7	4	4	3	4	7	4	4	2	3	2	2	–	1	–	–	–	–	–	–	–	64
larreae	♀N	–	–	1	1	–	–	1	1	–	3	2	3	–	1	4	4	5	4	4	5	5	5	4	1	1	–	55
	♂N	–	–	–	2	15	10	1	7	3	7	5	17	10	11	4	17	9	12	18	13	11	8	6	2	3	1	192
Xylocopa	♀P	–	–	10	6	10	1	3	3	1	5	4	3	–	–	–	1	4	–	–	3	–	1	–	–	–	–	55
californica	♀N	–	–	1	2	6	8	2	1	1	1	3	1	–	–	–	1	6	1	1	1	–	1	–	–	–	–	37
arizonensis	♂N	–	–	3	15	15	4	5	5	8	11	14	13	2	–	2	9	9	12	2	6	3	11	–	–	–	–	149
Centris	♀P	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	3
cockerelli	♀N	–	–	2	–	4	2	2	1	2	2	2	2	2	3	3	4	3	4	2	3	6	8	1	2	4	5	69
	♂N	–	–	5	1	6	–	–	–	–	2	–	2	3	1	3	3	1	3	–	–	2	2	1	–	–	2	37
Colletes	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
lousiae	♀N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	1	10	2	–	–	–	3	3	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20
Colletes	♀P	–	–	–	2	1	–	1	3	2	1	3	3	1	–	–	–	–	–	–	–	–	–	2	–	–	–	19
wootoni	♀N	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2
	♂N	–	–	–	2	–	4	1	2	3	–	4	3	1	–	1	1	1	–	–	1	–	–	–	2	1	1	28
Colletes	♀P	–	–	–	2	4	2	1	1	–	1	–	–	–	–	–	1	2	1	1	1	–	1	–	1	–	–	19
salicicola	♀N	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	1	1	6
	♂N	–	–	–	4	3	1	5	3	–	1	–	1	–	1	–	–	1	–	–	1	–	2	–	–	1	1	25
Colletes	♀P	–	–	–	1	–	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	7
covilleae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
	♂N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Bombus	♀P	–	–	–	2	–	–	1	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	5
sonorus	♀N	–	–	–	2	–	–	–	1	–	–	–	1	–	1	–	–	1	–	1	1	–	–	–	–	–	2	10
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Melissodes	♀P	–	–	–	–	–	–	–	–	1	1	1	2	2	1	3	2	1	–	–	1	1	3	–	–	1	–	20
tristis	♀N	–	–	–	–	–	–	–	–	–	1	1	–	3	1	2	–	–	–	–	2	–	1	1	–	–	1	13
	♂N	–	–	–	–	2	–	–	–	–	–	–	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–	6
Anthophora	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
californica	♀N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	1	1	2	–	1	–	2	–	–	–	–	9

Anthophora	♀P	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2
urbana	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	2	–	–	–	1	–	–	1	–	–	–	–	2	–	–	–	–	–	–	–	–	6
Hesperapis	♀P	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2
larreae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	2	–	2	–	1	–	–	–	–	–	–	2	–	1	–	–	–	–	–	–	–	8
Hoplitis	♀P	–	–	–	–	–	–	2	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
biscutellae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	–	–	4
Megachile	♀P	–	–	–	–	–	–	–	–	–	–	3	2	3	2	3	4	1	–	–	1	–	1	–	1	–	–	21
gentilis	♀N	–	–	–	–	–	1	–	–	1	–	2	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	6
	♂N	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	1	–	2	–	–	–	–	5
Megachile	♀P	–	–	–	–	–	1	–	1	–	1	1	1	1	1	2	5	7	4	1	1	4	6	4	2	5	1	49
texana	♀N	–	–	–	–	–	–	–	–	–	1	–	–	3	3	–	2	1	2	–	1	–	–	–	–	3	–	16
	♂N	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	2	–	–	–	1	–	–	2	–	2	–	10
Chalicodoma	♀P	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	–	4
discorhina	♀N	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
pallida	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	2
	♂N	–	–	–	–	–	–	1	–	–	–	–	2	–	–	1	1	1	3	2	1	7	–	–	–	–	–	19
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
hoffmanseggiae	♀N	–	–	–	–	–	–	–	–	–	1	1	1	–	–	1	–	1	1	1	–	–	–	–	2	–	–	9
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Anthidium	♀P	–	–	–	–	–	–	–	–	–	2	–	–	2	–	–	–	1	–	1	2	–	–	1	1	2	–	12
cockerelli	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2
	♂N	–	–	–	–	–	–	–	–	1	1	1	–	–	1	2	–	1	–	–	1	2	–	–	–	1	–	11
Chalicodoma	♀P	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	–	1	–	1	–	–	–	1	–	–	–	6
chilopsidis	♀N	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	1	–	–	1	–	–	–	–	4
	♂N	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	5
Miscellaneous	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	1	–	–	–	–	–	–	3
species [1]	♀N	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	–	–	–	6
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Totals		–	–	25	61	79	46	32	38	32	57	60	70	41	31	39	66	64	54	42	51	42	59	24	17	26	16	1072

[1] Miscellaneous species in small numbers included one pollen-collecting and two nectar-drinking females of *Xylocopa varipuncta*, one pollen-collecting female of *Nomia angustitibialis* (1230–1259), pollen-collecting females of *Megachile sidalceae, M. fucata, Chalicodoma lobatifrons, C. occidentalis, Ashmeadiella breviceps, Halictus tripartitus,* and males of *Chalicodoma spinotulata, Colletes clypeonitens,* and *Nomia mesillensis.* Three examples of *Centris atripes* were taking nectar only. Parasitic bees included one female of *Ericrocis arizonensis* and a male of *Epeolus mesillae. Perdita larreae, P. semicaerulea,* and several species of *Dialictus* were present in significant numbers but were not sampled consistently.

TABLE 6.—*Portal, Arizona, 1 mile N, August: Half-hour samples of principal species* (P=pollen; N=nectar; *=no sample; centrigrade temperatures in parentheses; sunrise: 0540; sunset: 1817; sky largely clear; broken clouds in afternoon; collectors E. G. and J. M. Linsley)

Species		0500 0529	0530 0559 (24)	0600 0629 (23)	0630 0659 (25)	0700 0729 (28)	0730 0759 (29)	0800 0829 (30)	0830 0859 (31)	0900 0929 (32)	0930 0959 (33)	1000 1029 (35)	1030 1059 (36)	1100 1129 (37.5)	1130 1159 (38)	1200 1229 (38)	1230 1259 (38)	1300 1329 (38)	1330 1359 (37)	1400 1429 (37)	1430 1459 (36.5)	1500 1529 (36)	1530 1559 (34)	1600 1629 (32)	1630 1659 (31.5)	1700 1729 (30.5)	1730 1759 (29)	1800 1829 (28)	1830 1859 (27)	1900 1929 (25.5)	1930 1959	*Totals*
Caupolicana yarrowi	♀P	–	4	2	1	4	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	16
	♀N	–	–	2	7	6	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	2	–	–	–	27
	♂N	–	–	–	2	11	6	3	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	8	11	–	–	–	47
Ptiloglossa arizonensis	♀P	–	2	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
	♀N	–	3	6	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14
	♂N	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Martinapis luteicornis	♀P	–	–	2	2	3	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	14
	♀N	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
	♂N	–	–	–	–	–	1	2	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	1	–	–	–	9
Agapostemon angelicus	♀P	–	–	3	4	16	3	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	1	–	–	–	–	35
	♀N	–	–	–	–	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	1	–	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	5
Agapostemon melliventris	♀P	–	–	–	–	6	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11
	♀N	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Melissodes tristis	♀P	–	–	–	5	6	3	4	3	4	8	16	19	4	5	2	2	4	3	4	6	–	3	–	1	–	–	–	–	–	–	102
	♀N	–	–	–	–	–	3	–	2	–	4	2	1	4	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	18
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Exomalopsis solani	♀P	–	–	–	3	7	11	8	7	6	9	8	9	10	6	3	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	89
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Xylocopa arizonensis	♀P	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♀N	–	–	–	1	3	2	1	1	2	2	1	7	4	1	3	3	2	3	12	8	2	2	–	–	–	–	–	–	–	–	–	60
	♂N	–	–	–	–	–	–	–	–	2	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Megachile texana	♀P	–	–	–	–	1	3	2	6	5	6	6	8	6	4	3	4	2	4	3	3	2	4	3	–	–	–	–	–	–	–	–	75
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	1	–	–	–	–	–	–	–	4
	♂N	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	6

Nomia	♀P	–	–	–	–	–	–	–	1	3	3	4	5	5	2	1	3	5	8	3	1	3	2	–	–	–	–	–	–	–	–	49
mesillensis	♀N	–	–	–	–	–	–	1	1	–	–	1	–	2	3	2	1	–	3	–	–	1	1	–	–	–	–	–	–	–	–	16
	♂N	–	–	–	–	–	1	1	–	–	1	–	2	3	–	–	–	–	3	–	–	1	2	–	–	–	–	–	–	–	–	14
Bombus	♀P	–	–	–	5	3	2	2	1	2	6	4	3	2	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	32
sonorus	♀N	–	–	–	–	–	–	–	–	–	3	6	5	6	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	23
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Protoxaea	♀P	–	–	–	1	3	1	4	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
gloriosa	♀N	–	–	–	1	–	1	1	3	1	2	–	–	–	1	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
	♂N	–	–	–	–	–	1	1	–	2	1	5	2	2	–	–	–	–	–	–	6	2	–	–	–	–	–	–	–	–	–	22
Megachile	♀P	–	–	–	–	1	1	2	1	2	–	–	–	1	–	–	1	–	–	–	–	1	–	2	–	–	–	–	–	–	–	12
sidalceae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	2
Miscellaneous	♀P	–	–	2	1	3	2	1	1	–	1	–	2	–	1	–	1	–	–	–	2	–	–	1	–	–	–	–	–	–	–	18
species[1]	♀N	–	–	1	2	1	1	–	2	1	–	3	1	2	–	1	–	2	–	1	–	–	2	–	4	–	–	–	–	–	–	24
	♂N	–	–	–	–	3	1	–	1	–	1	–	2	–	1	–	2	3	4	–	1	–	–	–	–	–	–	–	–	–	–	19
Totals		–	9	23	41	87	59	38	44	32	49	60	67	52	25	20	22	18	37	25	28	12	16	10	8	7	20	15	–	–	–	824

[1] Miscellaneous polyleges in small numbers included *Agapostemon tyleri*, ♂♂, ♀♀P; *Anthophora californica texana*, ♀N; *Anthophora urbana*, ♂♂, ♀N; *Chalicodoma occidentalis*, ♀♀P; *Chalicodoma spinotulata*, ♂♂, ♀♀P; *Colletes wootoni*, ♂, ♀P; *Dialictus* spp. ♂♂, ♀♀P; *Megachile pugnata*, ♀♀P; *Megachile gentilis*, ♂♂; *Melissodes paroselae*, ♀♀P; *Triepeolus* spp., ♂♂, ♀♀N. *Perdita* are not included in these tables since they were not sampled systematically. The most abundant species was *P. larreae*, although *P. semicaerulea* was also well represented.

TABLE 7.—*Douglas, Arizona, May: Half-hour samples of principal species* (P=pollen; N=nectar only; centigrade temperatures in parentheses; sky clear but clouds in afternoon; sunrise: 0525; sunset: 1915; collections by P. D. Hurd, Jr., E. G. and J. M. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529 (13)	0530 0559 (14)	0600 0629 (14.5)	0630 0659 (19)	0700 0729 (21)	0730 0759 (22.5)	0800 0829 (25)	0830 0859 (28.5)	0900 0929 (28)	0930 0959 (28)	1000 1029 (29)	1030 1059 (29)	1100 1129 (30)	1130 1159 (30)	1200 1229 (30.5)	1230 1259 (30.8)	1300 1329 (31)	1330 1359 (31.5)	1400 1429 (31.5)	1430 1459 (32)	1500 1529 (33)	1530 1559 (32)	1600 1629 (33)	1630 1659 (33)	1700 1729 (32)	1730 1759 (30)	1800 1829 (29.3)	*Totals*
Colletes salicicola	♀P	–	–	10	12	18	10	6	10	–	–	4	2	1	2	1	3	3	1	1	4	4	4	4	4	5	–	–	109
	♀N	–	–	–	1	–	2	–	–	2	–	–	–	–	–	1	–	–	–	–	–	3	–	–	2	–	3	5	19
	♂N	–	–	–	–	1	–	1	–	–	–	–	1	–	12	1	–	–	–	–	–	–	–	2	–	1	–	–	19
Colletes wootoni	♀P	–	–	1	3	2	4	7	3	2	–	3	9	4	2	–	3	1	4	1	1	2	1	2	6	2	1	–	64
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
	♂N	–	–	–	–	–	–	2	1	–	–	1	1	–	1	1	–	–	1	–	–	–	–	–	1	1	–	–	10
Colletes louisae	♀P	–	–	1	1	–	–	2	–	–	–	2	4	2	1	–	–	–	1	2	–	1	–	3	2	2	1	2	27
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1	–	–	–	–	–	4
Agapostemon angelicus	♀P	–	–	1	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	2	1	11
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	1	1	1	1	2	1	–	1	–	–	–	2	–	–	–	–	–	2	–	–	–	2	1	1	16
Centris hoffmanseggiae	♀P	–	–	–	–	–	–	–	–	1	–	2	1	–	–	2	1	1	1	–	–	–	–	2	2	–	–	–	13
	♀N	–	–	2	2	1	1	2	2	–	1	1	–	–	–	2	1	1	1	–	1	1	3	1	2	3	3	–	31
	♂N	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Heteranthdium larreae	♀P	–	–	–	–	–	2	7	3	2	1	2	2	1	1	1	2	–	–	–	–	–	–	–	–	–	–	–	24
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1	–	–	–	–	1	4	2	–	–	–	–	10
	♂N	–	–	–	3	2	1	1	3	3	8	4	9	2	1	1	2	1	3	7	4	9	4	11	–	1	2	–	82
Colletes clypeonitens	♀P	–	–	–	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
	♀N	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Colletes covilleae	♀P	–	–	–	1	–	1	1	–	–	–	2	–	–	–	–	–	1	–	–	–	–	–	1	1	–	–	–	8
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Melissodes tristis	♀P	–	–	–	–	–	1	2	2	1	–	–	–	–	–	1	–	–	–	–	–	–	1	2	1	–	–	–	11
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0

Hesperapis	♀P	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	1	–	1	–	–	–	–	–	4
larreae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	3	2	10
Megachile	♀P	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	1	–	2	–	–	2	1	–	–	8
texana	♀N	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–	–	4
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	1	–	–	–	3
Megachile	♀P	–	–	–	–	–	–	–	–	–	–	1	–	1	–	1	–	–	–	–	1	2	–	1	1	–	–	–	8
gentilis	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Hoplitus	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	1	2	2	–	–	8
biscutellae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	1	2	1	–	–	–	–	6
Anthophora	♀P	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	3
californica	♀N	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	5
	♂N	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	3
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
pallida	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	1	–	1	1	–	–	–	–	2	1	–	–	1	–	–	1	4	2	1	–	–	–	–	15
Anthidium	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	2
cockerelli	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	2
Miscellaneous	♀P	–	–	–	–	–	–	2	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	5
species[1]	♀N	–	–	–	–	–	–	–	–	1	–	1	2	1	–	–	–	2	–	–	–	–	1	1	–	–	–	–	9
	♂N	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	1	–	1	–	–	–	–	–	–	6
Totals		–	–	15	28	29	26	38	27	14	10	26	38	20	21	18	16	11	12	13	14	41	28	44	31	29	18	11	578

[1] Miscellaneous species in small numbers included pollen-collecting females of *Andrena prunorum, Chalicodoma chilopsidis,* and *Halictus tripartitus.* Nectar-drinking females included *Anthidiellum ehrhorni, Bombus sonorus, Centris atripes, Lasioglossum sisymbrii,* and *Xylocopa californica arizonensis.* Males of *Chalicodoma lobatifrons, Halictus ligatus, Megachile sidalceae,* and *Xylocopa varipuncta* were also taken. *Perdita semicaerulea* were active from 0700 to 1659, *P. larreae* from 0830 to 1629, and *Dialictus* spp. from 0630 to 1829.

TABLE 8.—*Douglas, Arizona, August: Half-hour samples of principal species at airport* (P=pollen; N=nectar; sunrise: 0550; high thin cover of cirrus clouds; collections by E. G. and J. M. Linsley)

Species		0500 0529	0530 0559	0600 0629	0630 0659	0700 0729	0730 0759	0800 0829	0830 0859	0900 0929	0930 0959	1000 1029	1030 1059	1100 1129	1130 1159	1200 1229	1230 1259	1300 1329	1330 1359	1400 1429	1430 1459	*Totals*
Ptiloglossa	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
jonesi	♀N	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
	♂N	8	3	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14
Caupolicana	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
yarrowi	♀N	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	♂N	6	5	4	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19
Colletes	♀P	–	1	–	1	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	5
wootoni	♀N	–	2	3	3	5	3	4	5	4	4	3	4	2	–	–	–	–	–	–	–	42
	♂N	–	–	–	–	–	4	2	4	5	3	4	1	5	3	2	–	–	–	–	–	33
Agapostemon	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
melliventris	♀N	–	4	–	7	–	1	1	2	2	–	–	–	–	–	–	–	–	–	–	–	17
	♂N	–	–	–	–	–	2	2	–	–	–	–	–	–	–	1	–	–	–	–	–	5
Bombus	♀P	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	2
sonorus	♀N	–	–	1	–	–	1	3	–	1	1	2	–	–	–	–	–	–	–	–	–	9
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Martinapis	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
luteicornis	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Melissodes	♀P	–	–	–	1	5	8	5	6	13	10	3	12	9	8	3	3	2	2	3	4	97
tristis	♀N	–	–	–	2	2	–	6	5	1	1	4	2	2	1	–	2	2	3	4	2	39
	♂N	–	–	–	–	–	–	–	1	–	2	–	1	2	–	3	1	–	–	–	–	10
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
atripes	♀N	–	–	–	–	–	–	1	–	2	–	2	2	3	4	2	1	1	1	1	–	20
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Xylocopa	♀P	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
arizonensis	♀N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Megachile	♀P	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
sidalceae	♀N	–	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Megachile	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
texana	♀N	–	–	–	–	–	–	–	–	–	1	2	1	–	–	–	–	–	–	–	–	4
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Miscellaneous	♀P	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
species[1]	♀N	–	–	–	–	–	–	–	1	–	1	–	–	–	1	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	–	–	–	–	–	3
Totals		22	18	10	16	15	20	24	27	30	26	22	23	26	17	13	7	5	6	8	7	342

[1] Miscellaneous species present in small numbers included *Agapostemon angelicus, Chalicodoma lobatifrons,* and *Melissodes paroselae.*

TABLE 9.—*Tucson, Arizona, 18 miles W, May: Half-hour samples of principal species* (P=pollen; N=nectar only; centrigrade temperatures in parentheses; sunrise: 0520; sunset: 1915; collections by P. D. Hurd, Jr., E. G. and J. M. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529	0530 0559 (15)	0600 0629 (15)	0630 0659 (17.5)	0700 0729 (18.5)	0730 0759 (22.5)	0800 0829 (24.5)	0830 0859 (26.5)	0900 0929 (29)	0930 0959 (31.5)	1000 1029 (33)	1030 1059 (34)	1100 1129 (35.5)	1130 1159 (35.5)	1200 1229 (35.5)	1230 1259 (35.5)	1300 1329 (36.5)	1330 1359 (36)	1400 1429 (36)	1430 1459 (36)	1500 1529 (36)	1530 1559 (35)	1600 1629 (34.5)	1630 1659 (33)	1700 1729 (33)	1730 1759 (32)	1800 1829 (32)	*Totals*
Synhalonia	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
venusta	♀N	–	–	–	1	–	1	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
	♂N	–	1	7	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11
Ancylandrena	♀P	–	–	4	2	3	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14
larreae	♀N	–	3	3	5	3	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
	♂N	–	–	1	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Colletes	♀P	–	1	1	9	7	3	2	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	4	33
covilleae	♀N	–	1	1	1	–	–	–	2	–	–	–	–	–	1	–	–	1	–	–	–	–	–	1	–	–	–	–	8
	♂N	–	–	–	3	2	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	1	1	1	–	–	10
Colletes	♀P	–	–	–	–	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
salicicola	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	3	–	1	2	–	1	1	1	2	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	13
Hesperapis	♀P	–	–	–	–	1	10	8	9	5	5	1	2	1	–	1	–	–	–	1	–	–	1	–	–	–	–	–	45
larreae	♀N	–	–	1	–	3	–	–	–	1	–	1	–	1	1	–	–	–	–	–	–	1	2	2	2	1	4	4	24
	♂N	–	3	1	–	–	3	3	6	5	3	–	–	–	–	–	–	–	1	–	–	–	3	8	2	1	–	5	44
Hoplitus	♀P	–	–	–	11	6	2	4	5	4	6	2	2	1	3	1	–	–	–	–	3	1	2	2	–	9	4	3	71
biscutellae	♀N	–	–	–	–	–	–	–	–	1	2	–	–	1	–	–	–	–	–	–	–	–	–	1	–	1	1	1	8
	♂N	–	1	–	1	–	1	1	3	1	1	1	2	–	–	1	–	–	–	–	–	–	3	1	–	1	–	2	20
Heteranthidium	♀P	–	–	1	7	24	26	25	35	25	16	20	14	9	13	8	10	1	5	4	3	2	–	2	–	–	–	–	250
larreae	♀N	–	–	3	19	25	17	14	16	18	11	22	15	15	11	7	18	9	4	9	4	9	6	12	8	8	22	16	318
	♂N	–	–	2	26	62	85	39	60	54	42	47	37	29	34	75	54	44	45	36	40	26	37	37	22	39	13	56	1041
Lasioglossum	♀P	–	–	2	11	7	8	3	3	4	2	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1	–	44
sisymbrii	♀N	–	–	–	–	1	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	4
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris	♀P	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
cockerelli	♀N	–	–	1	2	3	2	2	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	11
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Andrena	♀P	–	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
fracta	♀N	–	–	–	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Centris	♀P	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
hoffmanseggiae	♀N	–	–	1	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
pallida	♀N	–	–	–	–	–	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	3
Miscellaneous	♀P	–	–	–	–	–	–	–	1	1	–	–	–	1	2	–	–	–	–	–	–	–	–	1	–	–	–	–	6
species[1]	♀N	–	–	–	–	1	–	1	–	2	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	6
	♂N	–	–	–	1	1	1	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	7
Totals		–	13	29	108	155	164	112	149	127	95	97	73	58	66	94	83	55	56	50	51	39	54	69	39	62	45	94	2037

[1] Miscellaneous species present in small numbers included pollen-collecting females of *Anthidium cockerelli, Chalicodoma lobatifrons, Colletes clypeonitens, Centris rhodopus, Ceratina apacheorum, Agapostemon cockerelli,* and *Nomia tetrazonata.* Nectar-drinking females were represented by *Agapostemon melliventris, Halictus tripartitus, Martinapis luteicornis, Megachile gentilis, M. texana,* and males by *Colletes louisae.* Honeybees first appeared at 0610. *Perdita semicaerulea* were active from 0530 to 1800, *P. lateralis* from 0630 to 1800, and *Dialictus* spp. from 0600 to 1800.

TABLE 10.—*Tucson, Arizona, August: Half-hour samples of principal species* (P=pollen; N=nectar only; centigrade temperatures in parentheses; sunrise: 0602; sky clear or with broken clouds; slight breeze; collections by E. G. and J. M. Linsley)

Species		0500 0529 (23)	0530 0559 (23)	0600 0629 (24)	0630 0659 (24.5)	0700 0729 (25)	0730 0759 (25.5)	0800 0829 (26.5)	0830 0859 (28)	0900 0929 (28.5)	0930 0959 (29)	1000 1029 (29.5)	1030 1059 (30)	1100 1129 (30.5)	1130 1159 (31.5)	1200 1229 (32)	1230 1259 (32.5)	1300 1329 (32.5)	1330 1359 (32.5)	1400 1429 (33)	1430 1459 (34)	1500 1529 (34)	1530 1559 (34)	1600 1629 (34)	1630 1659 (34)	1700 1729 (33)	*Totals*
Agapostemon tyleri	♀P	–	13	17	18	12	4	3	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	70
	♀N	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Protoxaea gloriosa	♀P	–	–	4	6	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	1	1	2	3	4	1	1	1	1	–	–	1	–	–	–	–	–	–	–	–	–	16
Melissodes tristis	♀P	–	–	8	11	21	12	12	8	3	1	–	–	–	–	–	–	2	3	3	2	–	1	2	1	–	90
	♀N	–	–	–	–	2	2	3	6	1	1	–	–	–	–	1	–	–	1	2	1	–	–	–	–	–	20
	♂N	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	1	–	–	1	–	–	–	4
Centris rhodopus	♀P	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	♀N	–	–	–	1	2	3	3	3	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	20
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Nomia tetrazonata	♀P	–	–	–	3	8	18	29	19	26	29	31	25	24	22	29	26	21	19	21	13	13	7	7	1	–	391
	♀N	–	–	–	1	–	6	8	16	14	12	19	13	18	13	10	4	12	15	15	11	10	3	3	1	1	205
	♂N	–	–	–	–	–	–	–	–	–	2	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	4
Xylocopa C. arizonensis	♀P	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♀N	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Megachile sidalceae	♀P	–	–	–	–	–	–	1	3	–	–	1	1	5	1	–	–	2	3	2	3	–	–	2	2	–	26
	♀N	–	–	–	–	–	–	2	2	1	4	1	–	1	–	–	–	–	–	–	1	–	–	–	–	–	12
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Megachile texana	♀P	–	–	–	–	–	2	1	–	1	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	6
	♀N	–	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Miscellaneous species[1]	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	–	–	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
	♂N	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Totals		–	13	30	41	50	50	65	65	59	53	55	42	51	37	40	31	37	41	44	32	24	12	15	6	3	896

[1] Miscellaneous species included females of the parasitic bees *Ericrocis arizonensis*, *Triepeolus verbesinae*, and *Triepeolus* sp. Honeybees were present in small numbers in the early morning. *Agapostemon angelicus* and *A. melliventris* were visiting the flowers at the same time as *A. tyleri*.

TABLE 11.—*Tucson Airport, May: Half-hour samples of principal species* (P=pollen; N=nectar only; centrigrade temperatures in parentheses; sunrise: 0519; sunset: 1915; collections by P. D. Hurd, Jr., and A. E. and M. M. Michelbacher)

Species		0600 0614	0615 0644	0645 0714	0715 0744 (21.5)	0745 0814 (24.5)	0815 0844 (26)	0845 0914 (26)	0915 0944 (27.5)	0945 1014 (28)	1015 1044 (30)	1045 1114 (31.5)	1115 1144 (32.5)	1145 1214 (32.5)	1215 1244 (32.5)	1245 1314 (33)	1315 1344 (33)	1345 1414 (32.5)	1415 1444 (32)	1445 1514 (32)	1515 1544 (31)	1545 1614 (30)	1615 1644 (29.5)	1645 1714 (29.5)	1715 1744 (29)	*Totals*
Heteranthdium	♀P	–	–	2	4	6	7	5	4	4	8	16	10	6	2	12	–	4	4	–	2	–	–	–	–	96
larreae	♀N	–	–	–	2	–	–	–	3	5	3	3	6	–	4	5	2	3	1	2	3	2	1	5	–	50
	♂N	–	–	8	7	8	8	4	11	11	11	40	18	10	10	29	12	6	3	4	12	1	3	7	–	223
Lasioglossum	♀P	–	–	2	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
sisymbrii	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Colletes	♀P	–	–	2	–	1	–	2	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	7
salicicola	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Hesperapis	♀P	–	–	–	1	–	–	1	1	3	–	1	2	–	2	1	2	2	1	2	1	1	2	1	–	24
larreae	♀N	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	3
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Hoplitis	♀P	–	–	–	–	–	–	1	–	1	1	2	–	–	1	1	–	–	1	–	–	–	2	1	–	11
biscutellae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	1	–	–	3
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
cockerelli	♀N	–	–	–	1	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	♂N	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Colletes	♀P	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
covilleae	♀N	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	1	–	–	–	–	3
	♂N	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Ancylandrena	♀P	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
larreae	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♂N	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Anthidium	♀P	–	–	–	1	–	1	–	1	–	–	–	1	1	–	–	–	1	1	–	–	2	2	–	–	11
cockerelli	♀N	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	2
	♂N	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	2
Megachile	♀P	–	–	–	–	–	1	–	–	1	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	4
texana	♀N	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
pallida	♀N	–	–	–	–	–	1	–	–	–	1	–	1	–	–	–	–	5	–	–	–	–	–	–	–	8
	♂N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
Megachile	♀P	–	–	–	–	–	–	–	–	–	1	–	1	–	1	–	–	–	2	–	–	–	–	–	–	5
gentilis	♀N	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	2
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
hoffmanseggiae	♀N	–	–	–	–	–	–	–	1	–	1	–	1	–	–	1	–	–	–	–	–	–	–	–	–	4
	♂N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Miscellaneous	♀P	–	–	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	4
species[1]	♀N	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3
	♂N	–	–	–	–	1	1	–	–	–	–	–	1	1	–	2	–	–	–	–	1	–	–	–	–	7
Totals		–	–	19	25	20	25	16	23	27	31	63	42	18	21	52	18	22	14	9	21	9	13	14	1	503

[1] Miscellaneous species in small numbers included pollen-collecting females of *Chalicodoma chilopsidis* and *Colletes louisae*, nectar-drinking females of *Agapostemon melliventris* and *Dioxys productus semirubrus*, and males of *Agapostemon angelicus*, *Ashmeadiella breviceps*, *Centris rhodopus*, *Chalicodoma occidentalis*, and *Megachile howardi*. *Perdita covilleae* were present from 0745.

TABLE 12.—*Yuma, Arizona, and vicinity, April: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no sample; centigrade temperatures in parentheses; sunrise: 0535; sky clear or with broken clouds; collections by P. D. Hurd, Jr., E. G. and J. M. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529	0530 0559	0600 0629	0630 0659 (16)	0700 0729	0730 0759 (19)	0800 0829	0830 0859 (21)	0900 0929	0930 0959 (21.5)	1000 1029	1030 1059 (27.5)	1100 1129	1130 1159 (30)	1200 1229	1230 1259 (30.5)	1300 1329	1330 1359 (33)	1400 1429	1430 1459	1500 1529	1530 1559	*Totals*
Martinapis luteicornis	♀P	–	–	2	16	11	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30
	♀N	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	•	2
	♂N	–	–	1	–	3	4	2	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	14
Emphoropsis pallida	♀P	–	–	–	3	5	2	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
	♀N	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	•	3
	♂N	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Colletes clypeonitens	♀P	–	9	43	50	35	27	16	7	1	2	1	–	2	4	–	–	–	–	–	–	–	–	197
	♀N	–	–	–	1	1	3	1	1	1	1	–	–	3	5	–	–	–	2	–	–	1	•	20
	♂N	–	–	7	24	27	35	27	2	8	1	30	35	19	21	9	4	2	5	1	10	13	–	280
Colletes salicicola	♀P	–	–	–	1	5	5	3	5	6	2	2	1	1	–	–	–	–	–	–	–	2	–	33
	♀N	–	–	–	–	–	–	1	–	–	1	–	–	–	1	–	–	–	3	–	–	–	•	6
	♂N	–	–	–	6	5	2	1	–	1	6	1	1	1	2	2	–	–	–	1	–	5	–	34
Ancylandrena larreae	♀P	–	–	–	1	4	1	2	6	3	1	4	3	–	–	–	–	–	–	–	–	–	–	25
	♀N	–	–	–	–	–	–	–	1	1	–	–	1	–	–	–	–	–	–	–	–	–	•	3
	♂N	–	–	–	–	–	–	–	1	1	1	2	–	–	–	–	–	–	–	–	–	–	–	5
Hesperapis larreae	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	•	1
	♂N	–	–	–	–	3	10	7	–	1	–	–	–	–	–	–	–	–	–	3	–	–	–	24
Heteranthidium larreae	♀P	–	–	–	–	–	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	3
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	•	1
	♂N	–	–	–	–	1	–	6	–	–	–	–	2	7	–	1	–	–	1	2	–	–	–	20
Epeolus mesillae	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	•	2
	♂N	–	–	–	–	–	–	–	–	1	1	–	3	2	3	1	–	–	1	–	–	–	–	12
Hoplitis biscutellae	♀P	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	2
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	•	0
	♂N	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	3	1	–	–	–	6
Miscellaneous species[1]	♀P	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	♀N	–	–	–	–	2	–	–	–	–	1	–	–	–	–	–	–	1	1	–	–	–	•	5
	♂N	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	4
Totals		–	9	53	103	103	91	73	27	29	21	44	46	38	36	14	4	3	16	8	12	21	–	751

[1] Miscellaneous species present in small numbers included *Agapostemon melliventris*, ♂ ♂ (1430–1459); *Anthophora hololeuca*, ♀ ♀N (0730–1029); *Anthidiellum ehrhorni*, ♀N (1330–1339); *Centris hoffmanseggiae*, ♀N (1400–1429); *C. cockerelli*, ♀P (1100–1130); *Colletes louisae*, ♂ (0630–0659); *Megachile* spp., ♂, ♀P (0930-1029); and *Megachile xerophila*, ♀N (0700–0729). Both sexes of *Perdita punctulata* were present in significant numbers, males predominating, along with a few *Perdita lateralis* and *Dialictus* females, but these were not sampled adequately or consistently. Honeybees were moderately numerous from 0600.

TABLE 13.—*Palm Springs, California, April: Half-hour samples of principal species* (P=pollen; N=nectar only; *=no sample; centigrade temperatures in parentheses; sunrise: 0541; sky clear or broken clouds; collections by P. D. Hurd, Jr., E. G. Linsley, and A. E. and M. M. Michelbacher)

Species		0500 0529	0530 0559 (16)	0600 0629	0630 0659 (20)	0700 0729	0730 0759 (24)	0800 0829	0830 0859 (28)	0900 0929	0930 0959 (31)	1000 1029	1030 1059	1100 1129	1130 1159	1200 1229	1230 1259	1300 1329	1330 1359	1400 1429	1430 1459	*Totals*
Ancylandrena larreae	♀P	–	10	29	30	39	33	29	23	17	4	6	2	–	1	2	1	2	–	1	–	229
	♀N	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	*	2
	♂N	–	1	8	10	13	7	12	8	5	1	–	–	–	–	1	–	–	–	2	–	68
Colletes clypeonitens	♀P	–	–	–	2	14	32	11	12	19	9	–	2	–	1	–	–	–	–	–	–	102
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	*	1
	♂N	–	–	–	–	17	16	36	63	68	86	13	7	4	1	1	28	6	1	–	–	347
Colletes salicicola	♀P	–	–	–	–	–	1	–	1	–	1	–	–	–	–	–	–	–	–	1	–	4
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	0
	♂N	–	–	–	–	4	4	12	14	28	25	6	7	2	2	7	–	2	–	1	–	114
Colletes larreae	♀P	–	–	–	1	–	1	2	2	–	–	–	–	–	1	–	–	–	–	–	–	7
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	0
	♂N	–	–	–	–	–	–	1	–	1	1	–	–	–	–	–	–	–	–	–	–	3
Hesperapis larreae	♀P	–	–	–	–	2	4	2	1	3	1	–	–	–	–	1	–	–	–	–	–	14
	♀N	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	*	2
	♂N	–	–	–	1	3	1	2	4	10	1	2	–	–	–	–	–	–	2	1	–	27
Hoplitis biscutellae	♀P	–	–	–	–	–	–	2	–	2	–	–	–	–	4	1	1	2	2	1	–	15
	♀N	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	*	2
	♂N	–	–	–	–	–	–	–	–	2	–	1	–	–	–	2	–	–	1	–	–	6
Perdita turgiceps	♀P	–	–	–	–	–	–	2	3	6	–	–	–	–	–	–	–	–	–	–	–	11
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	0
	♂N	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2
Xylocopa varipuncta	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	–	–	–	6	3	3	6	2	–	–	–	–	–	–	–	–	–	–	*	20
	♂N	–	–	–	–	–	–	–	1	–	1	–	–	–	1	–	–	–	1	–	–	4
Lasioglossum sisymbrii	♀P	–	–	–	–	1	–	–	–	1	1	3	2	–	–	1	1	–	–	–	–	10
	♀N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	0
	♂N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Centris cockerelli resoluta	♀P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
	♀N	–	1	–	–	–	–	3	–	–	–	1	–	–	1	–	–	–	–	–	*	6
	♂N	–	–	–	1	–	–	–	–	3	–	–	–	–	2	–	–	–	1	–	–	7
Miscellaneous species[1]	♀P	–	–	–	–	–	–	1	1	–	–	–	–	–	–	1	2	1	1	–	–	7
	♀N	–	–	–	–	–	–	–	1	1	–	1	2	–	1	1	–	–	–	–	*	7
	♂N	–	–	–	–	–	–	–	1	2	1	–	–	–	–	3	–	1	–	–	–	8
Totals		–	12	37	45	99	102	118	145	171	133	33	23	6	15	22	33	15	9	7	–	1025

[1] Miscellaneous species present in small numbers included *Agapostemon melliventris*, ♀♀P (0800–0859); *Andrena* sp., ♀P (1230–1259); *Anthophora hololeuca*, ♂ (0930–0959); *Anthophora urbana*, ♂ (0900–0929); *Colletes covilleae*, ♂♂ (0900–1229); *Epeolus mesillae palmarum*, ♂♂♀♀ (0830–1229); *Heteranthidium larreae*, ♀P, ♂♂ (1200–1429); *Hexepeolus rhodogyne*, ♂ (1300–1329); *Megachile gentilis*, ♀N (0900–0929), ♀P (1230–1259); *Megachile texana*, ♀♀N (1200–1229); *Nomadopsis larreae*, ♀♀P (1300–1429); *Synhalonia angustifrons*, ♀N (1130–1159); *Synhalonia sp.*, ♀N (1030–1059). *Perdita covilleae* and *P. lateralis* were present in significant numbers but could not be sampled adequately and consistently. The same was true of *Dialictus* spp., which, however, were present in smaller numbers. First honeybees: 0530–0559.

TABLE 14.—*Salome, Arizona, 27 April, 1973: Half-hour samples, unless otherwise indicated, of principal species from 5 large* Larrea *plants under continuous surveillance during each time period* (all females of those species listed in the table were collecting pollen except those of *Colletes salicicola* and *Chalicodoma discorhina;* sunrise: 0550; sunset: 1900; sky clear; wind moderate to strong; collections by G. E. Bohart)

Species[1]		0530 0544	0545 0559	0600 0614	0615 0629	0630 0644	0645 0659	0700 0714	0715 0729	0730 0744	0745 0814	0815 0844	0845 0914	0915 0944	0945 1014	1015 1044	1045 1114
Synhalonia venusta	♀	3	4	3	1	–	–	1	•	1	–	–	–	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Synhalonia cressoniana	♀	–	–	2	–	4	2	1	•	1	–	–	–	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Centris atripes	♀	–	–	1	–	–	1	4	•	2	2	–	–	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Colletes clypeonitens	♀	–	–	–	4	6	4	12	•	14	15	5	3	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Ancylandrena larreae	♀	–	–	–	–	1	1	1	•	1	1	2	–	–	1	–	–
	♂	–	–	–	1	1	–	–	•	2	2	3	1	–	–	1	–
Megandrena enceliae	♀	–	–	–	–	2	1	3	•	1	2	5	3	1	2	–	4
	♂	–	–	–	–	–	–	–	•	–	–	3	1	3	3	2	2
Hetanthidium larreae	♀	–	–	–	–	–	–	1	•	2	1	2	2	5	2	1	5
	♂	–	–	–	–	–	–	1	•	1	–	–	2	3	4	4	2
Megachile sidalceae	♀	–	–	–	–	–	–	–	•	–	1	1	1	1	2	1	1
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Colletes salicicola	♀	–	–	–	–	–	–	–	•	–	–	–	2	1	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Chalicodoma discorhina	♀	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Hoplitis biscutellae	♀	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
	♂	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–
Totals		3	4	6	6	14	9	24	–	25	24	21	15	14	14	9	14

[1] Miscellaneous species include *Dialictus microlepoides,* ♀ N; *Megachile howardi,* ♂; *Synhalonia douglasiana,* ♀ P; *Anthidium cockerelli,* ♀ P; *Centris pallida,* ♂, ♀ N; *Hesperapis larreae,* ♂, ♀ P; *Perdita punctulata,* ♂ ♂, ♀ ♀; *P. covilleae,* ♂ ♂, ♀ ♀; *P.* n. sp. near *ovaliceps,* ♂ ♂, ♀ ♀; *Colletes louisae,* ♂ ♂, and males of many species listed in the table. The species of *Perdita* appeared at the flowers about 0930 and became most abundant in midafternoon, remaining there until 1845. Males of *Colletes* appeared at the flowers at 0730 and were very abundant in midafternoon, but decreased in numbers as the evening hours approached.

1115 1144	1145 1214	1215 1244	1245 1314	1315 1344	1345 1429	1430 1459	1500 1529	1530 1559	1600 1629	1630 1659	1700 1729	1730 1759	1800 1829	1830 1844	1845 1859	1900 1915	*Totals*
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	7	5	25
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	–	–	•	–	–	–	–	–	–	–	•	–	1	1	–	12
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	1	–	•	–	–	–	1	–	–	–	•	–	–	–	–	12
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	6	3	72
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	8
–	–	–	1	•	–	–	–	–	–	–	–	•	–	–	–	–	12
6	4	5	1	•	1	2	1	1	1	–	–	•	–	7	2	–	55
2	6	4	3	•	4	6	5	2	3	1	–	•	–	–	–	–	50
3	2	1	1	•	1	–	1	1	1	–	1	•	–	–	–	–	33
1	2	6	4	•	3	2	4	2	3	4	1	•	1	–	–	–	50
–	1	–	–	•	–	–	–	–	–	–	–	•	1	–	–	–	10
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	3
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	1	–	1	•	–	–	–	1	–	–	–	•	–	–	–	–	3
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
–	–	–	–	•	–	–	–	–	1	1	–	•	2	1	–	–	5
–	–	–	–	•	–	–	–	–	–	–	–	•	–	–	–	–	0
12	16	17	11	–	9	10	11	8	9	6	2	–	4	9	16	8	350

TABLE 15.—*St. George, Utah, 30–31 May, 1973: Half-hour samples, except first and last periods, of principal species from 10 large* Larrea *plants under continuous surveillance during each time period* (most females were collecting pollen; centigrade temperatures in parentheses; sunrise: 0700; sunset: 1945; collections by G. E. Bohart)

Species		0545 0559 (21.5)	0600 0629	0630 0659	0700 0729	0730 0759	0800 0829 (29)	0830 0859	0900 0929	0930 0959	1000 1030	1030 1059	1100 1129	1130 1159	1200 1229	1230 1259
Synhalonia cressoniana	♀	4	13	2	2	–	–	–	–	–	–	–	–	–	–	–
	♂	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–
Centris cockerelli resoluta	♀	–	–	23	15	11	7	5	1	1	1	–	1	–	–	–
	♂	–	–	6	14	15	9	11	5	6	7	3	–	–	1	–
Colletes clypeonitens	♀	–	–	6	4	5	7	5	1	–	–	1	–	–	–	–
	♂	–	–	–	–	–	–	7	–	5	1	1	–	–	–	–
Heteranthidium larreae	♀	–	–	–	3	18	17	18	3	3	2	2	5	2	4	5
	♂	–	–	–	–	5	10	11	8	15	10	11	8	8	6	7
Hoplitis biscutellae	♀	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–
	♂	–	–	–	–	–	2	2	1	2	–	–	–	1	–	–
Perdita covilleae	♀	–	–	–	–	–	–	17	25	30	20	15	15	4	5	2
	♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Miscellaneous species[1]	♀	–	–	1	1	2	2	1	1	5	3	4	3	3	4	1
	♂	–	–	–	–	–	–	–	–	4	–	1	1	1	–	–
Totals		4	20	38	39	56	56	79	45	71	44	38	33	19	20	15

[1] Miscellaneous polyleges included *Agapostemon angelicus, Dialictus* spp., *Hylaeus* spp., *Megachile fucata, M. sidalceae,* and *Perdita* spp.

1300 1329 (36)	1330 1359	1400 1429	1430 1459	1500 1529	1530 1559	1600 1629	1630 1659	1700 1729 (36.5)	1730 1759	1800 1829	1830 1859	1900 1929	1930 1959	2000 2029	2030 2059	2100 2115 (29.5)	*Totals*
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	22
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
–	–	–	–	–	–	–	–	–	–	–	–	1	1	2	1	–	70
–	1	2	1	1	1	1	–	2	2	–	3	2	3	4	2	–	102
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	29
–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
4	6	4	4	6	4	5	4	4	5	4	4	4	6	6	2	1	155
8	10	9	8	5	9	10	7	9	5	5	6	5	2	1	1	–	199
–	–	–	–	–	–	–	1	–	–	–	1	1	1	3	2	–	13
–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	10
2	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	139
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